



US009401531B2

(12) **United States Patent**  
**Iida et al.**

(10) **Patent No.:** **US 9,401,531 B2**  
(45) **Date of Patent:** **Jul. 26, 2016**

(54) **HIGH-FREQUENCY SIGNAL  
TRANSMISSION LINE AND ELECTRONIC  
DEVICE**

USPC ..... 333/238, 246, 33, 34  
See application file for complete search history.

(71) Applicant: **Murata Manufacturing Co., Ltd.**,  
Nagaokakyo-shi, Kyoto-fu (JP)

(56) **References Cited**

U.S. PATENT DOCUMENTS

(72) Inventors: **Kanto Iida**, Nagaokakyo (JP); **Shigeru  
Tago**, Nagaokakyo (JP)

5,568,107 A \* 10/1996 Buuck ..... H01P 3/088  
333/238

5,631,446 A 5/1997 Quan

(Continued)

(73) Assignee: **MURATA MANUFACTURING CO.,  
LTD.**, Kyoto (JP)

FOREIGN PATENT DOCUMENTS

(\*) Notice: Subject to any disclaimer, the term of this  
patent is extended or adjusted under 35  
U.S.C. 154(b) by 218 days.

EP 0 928 041 A1 7/1999  
JP 06-350312 A 12/1994

(Continued)

(21) Appl. No.: **14/191,595**

OTHER PUBLICATIONS

(22) Filed: **Feb. 27, 2014**

Official Communication issued in International Patent Application  
No. PCT/JP2013/050934, mailed on Apr. 23, 2013.

(65) **Prior Publication Data**

US 2014/0176254 A1 Jun. 26, 2014

*Primary Examiner* — Stephen E Jones

(74) *Attorney, Agent, or Firm* — Keating & Bennett, LLP

**Related U.S. Application Data**

(63) Continuation of application No. PCT/JP2013/050934,  
filed on Jan. 18, 2013.

(57) **ABSTRACT**

A high-frequency signal transmission line includes a dielectric body including a plurality of dielectric sheets. A signal line is provided in the dielectric body. A connector is mounted on a first main surface of the dielectric body and electrically connected to the signal line. A ground conductor is provided on a second main surface side of the dielectric body, compared with the signal line, and faces the signal line across the dielectric sheet. In the ground conductor, conductor-missing portions are provided in which no conductors are provided in at least portions of regions overlapping with the signal line in planar in connection portions. Adjustment conductors are provided in the second main surface of the dielectric body, and overlap with at least portions of the conductor-missing portions in the planar view.

(30) **Foreign Application Priority Data**

Feb. 3, 2012 (JP) ..... 2012-022031

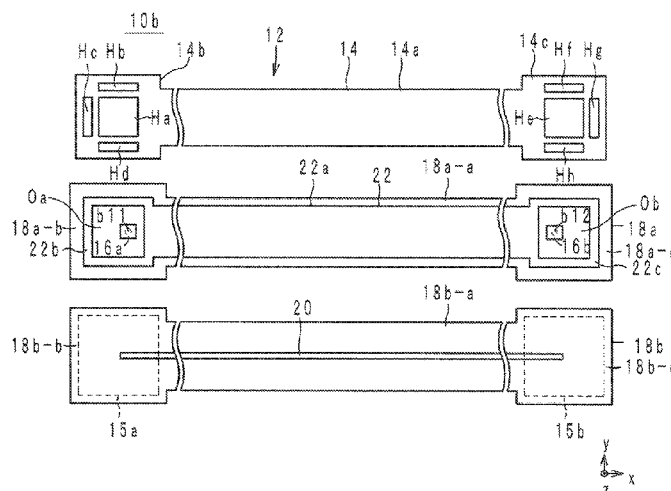
(51) **Int. Cl.**  
**H01P 3/08** (2006.01)  
**H03H 7/38** (2006.01)  
**H05K 1/02** (2006.01)

(52) **U.S. Cl.**  
CPC .. **H01P 3/08** (2013.01); **H03H 7/38** (2013.01);  
**H05K 1/0253** (2013.01);  
(Continued)

(58) **Field of Classification Search**

CPC ..... H03H 7/38; H01P 3/08

**20 Claims, 18 Drawing Sheets**



# US 9,401,531 B2

Page 2

(52) **U.S. Cl.**

CPC ... *H05K 1/0225* (2013.01); *H05K 2201/09327*  
(2013.01); *H05K 2201/09618* (2013.01); *H05K*  
*2201/09672* (2013.01); *H05K 2201/09727*  
(2013.01)

2014/0015623 A1 1/2014 Sherrer

## FOREIGN PATENT DOCUMENTS

(56)

### References Cited

#### U.S. PATENT DOCUMENTS

7,351,917 B2 \* 4/2008 Budell ..... H05K 1/0224  
174/255  
2008/0246562 A1 10/2008 Sherrer et al.

JP	09-139610 A	5/1997
JP	3161281 B2	4/2001
JP	2003-008310 A	1/2003
JP	2006-186436 A	7/2006
JP	2006-279481 A	10/2006
JP	2009-005335 A	1/2009
JP	2010-028345 A	2/2010

\* cited by examiner

FIG. 1A

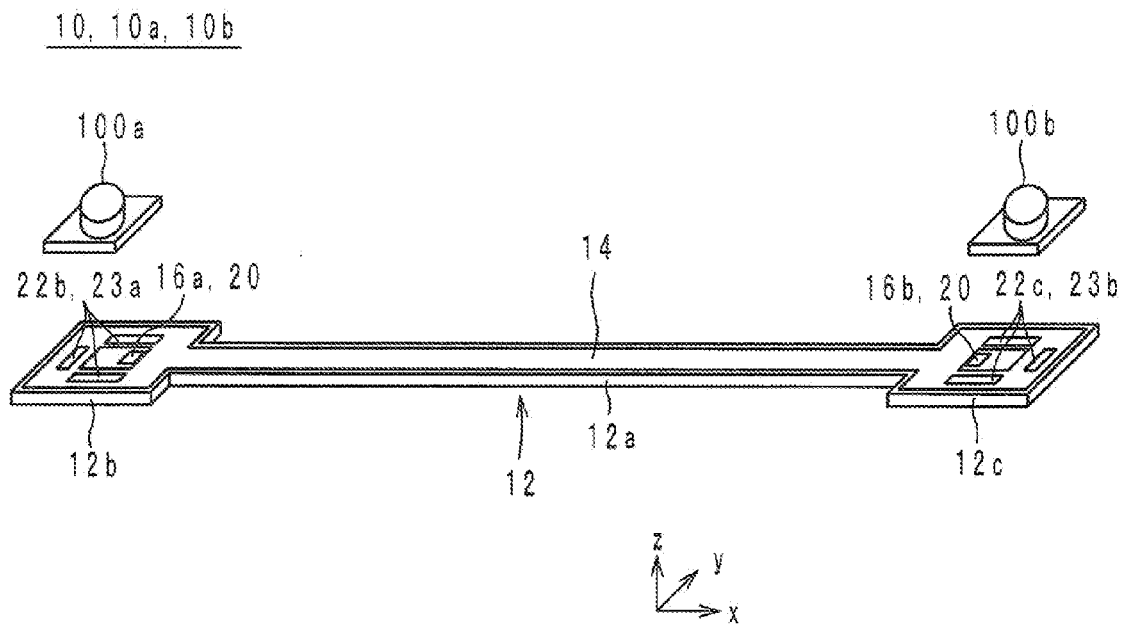


FIG. 1B

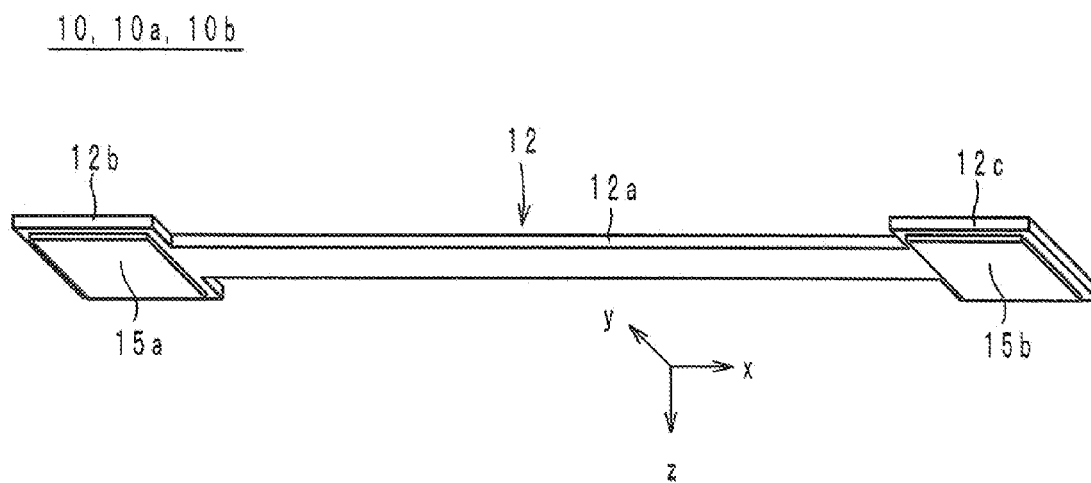


FIG. 2

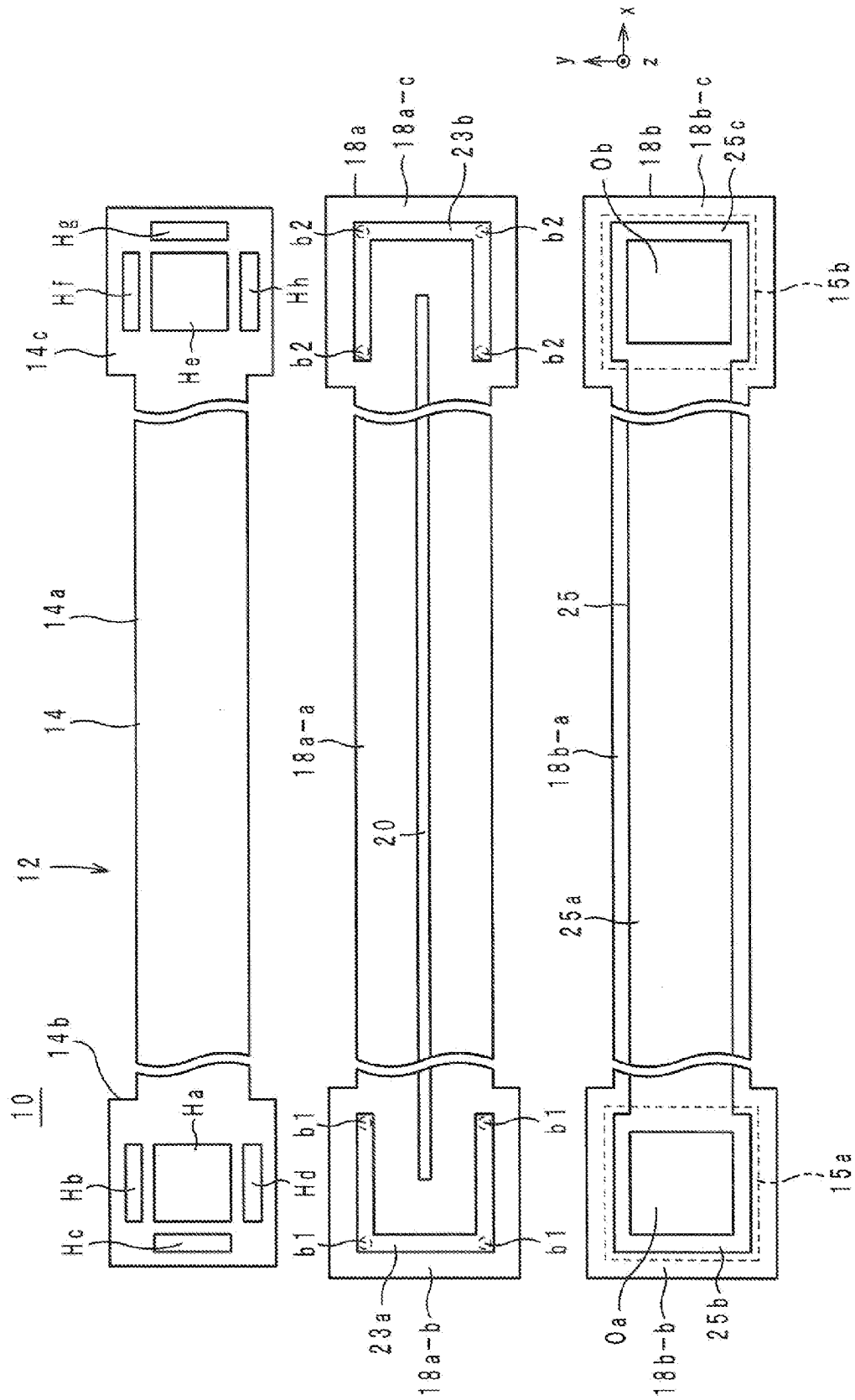


FIG. 3

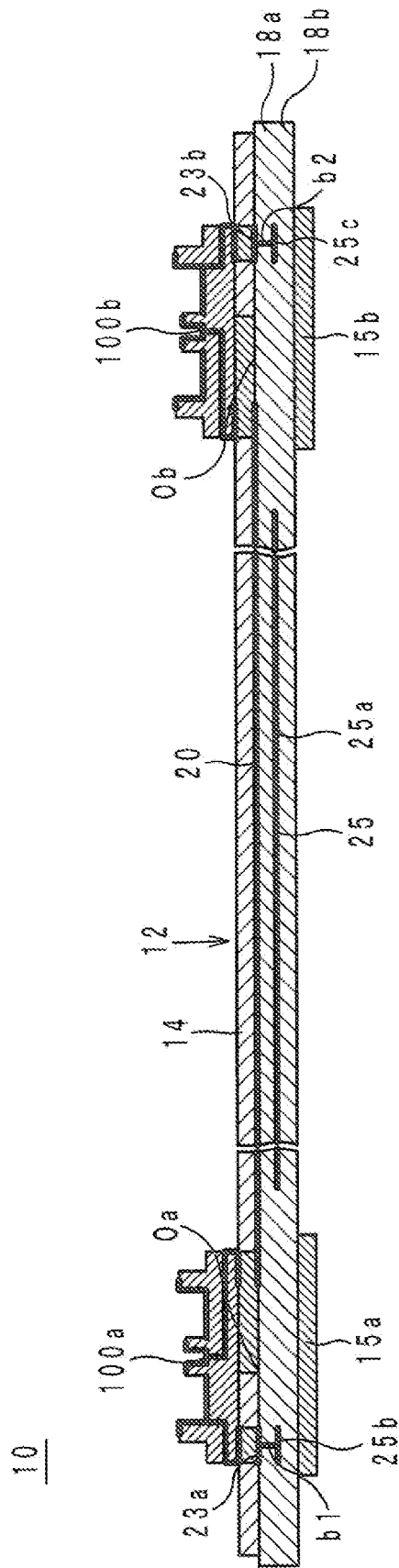


FIG. 4A

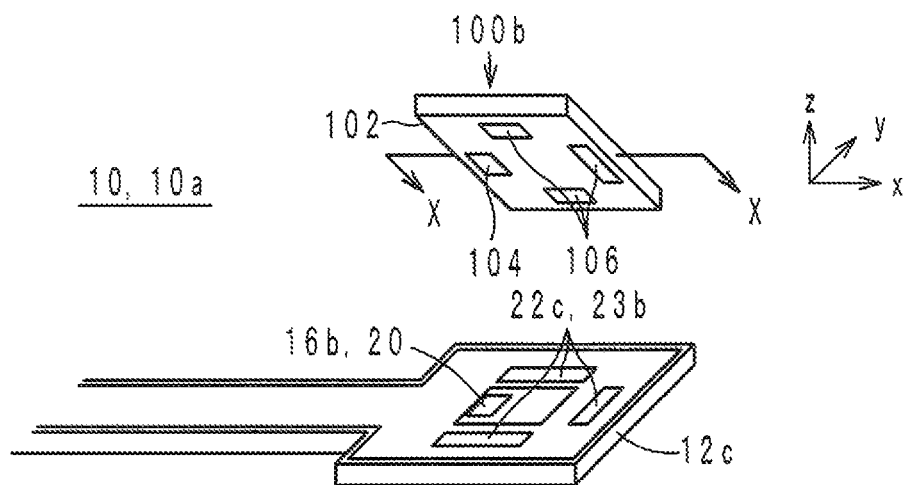


FIG. 4B

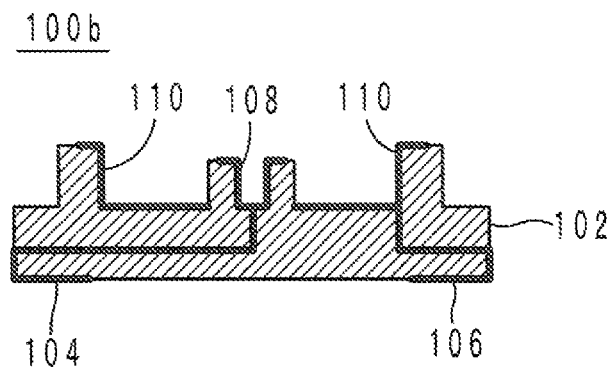


FIG. 5A

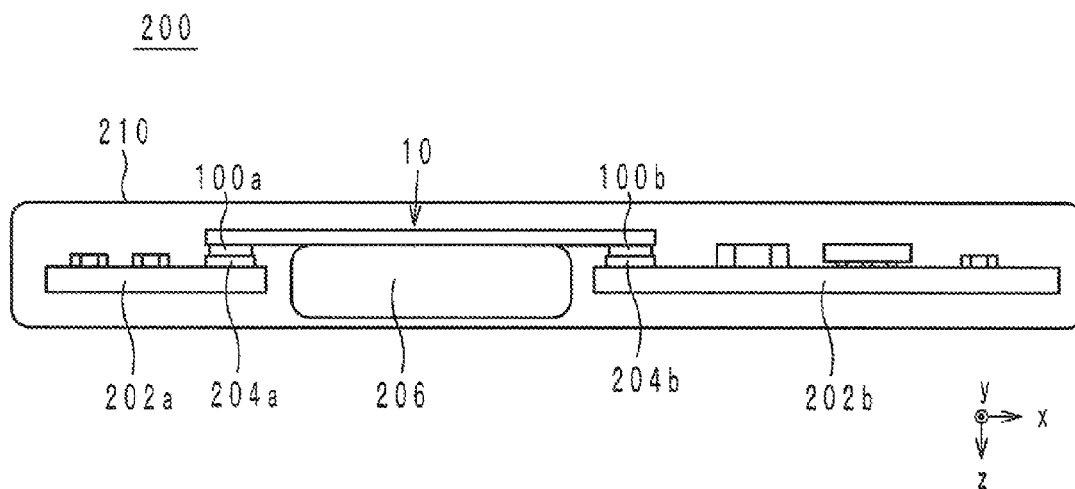


FIG. 5B

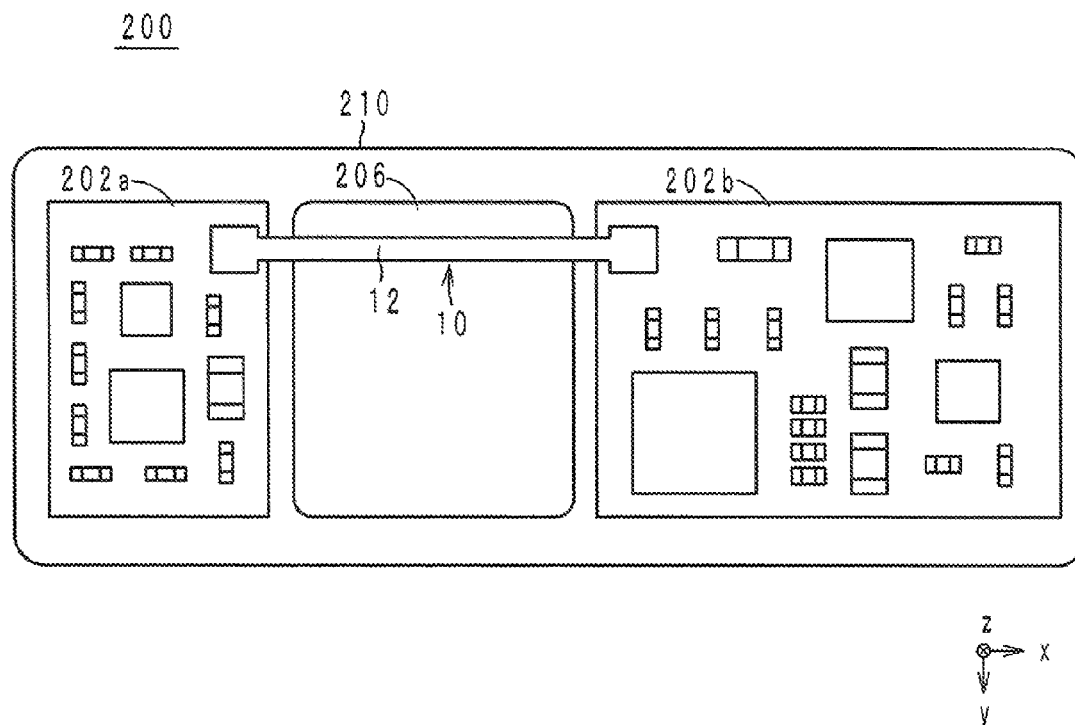


FIG. 6

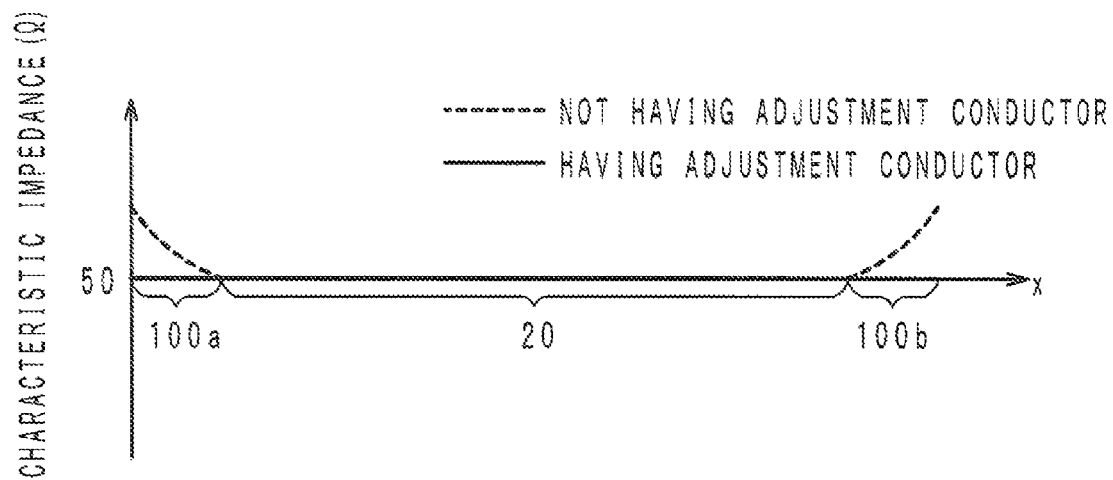


FIG. 7

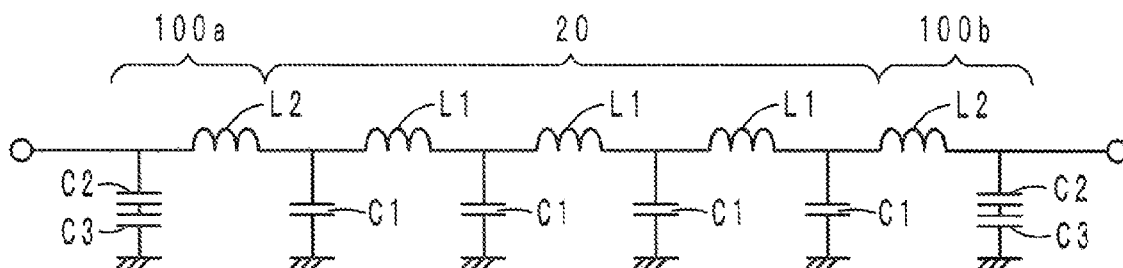




FIG. 8

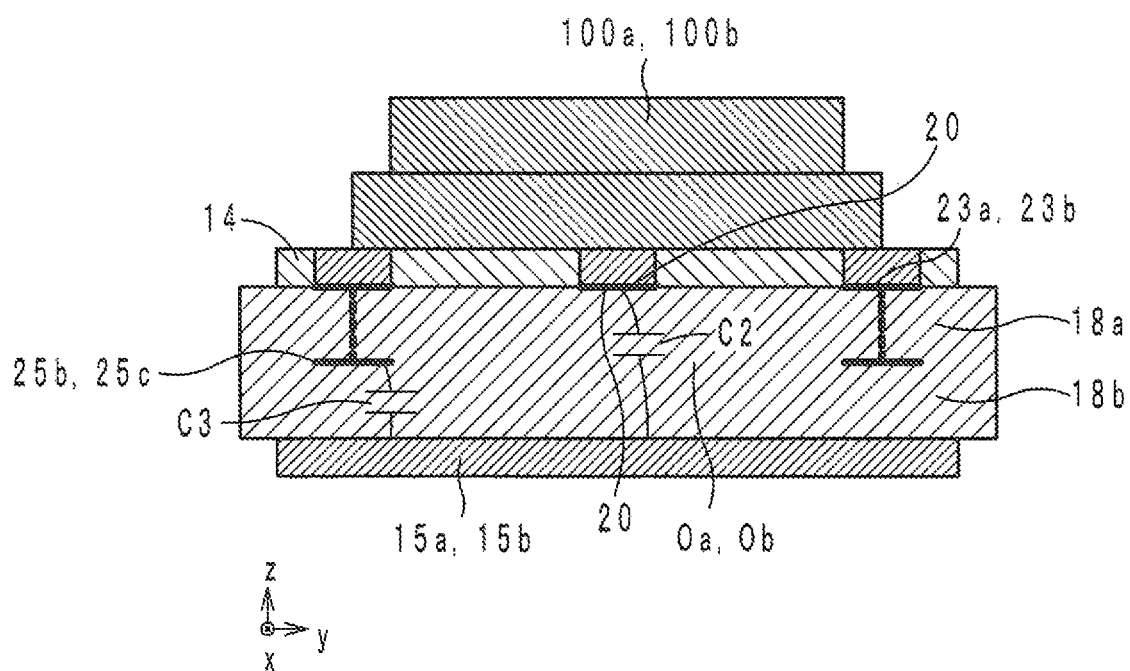


FIG. 9

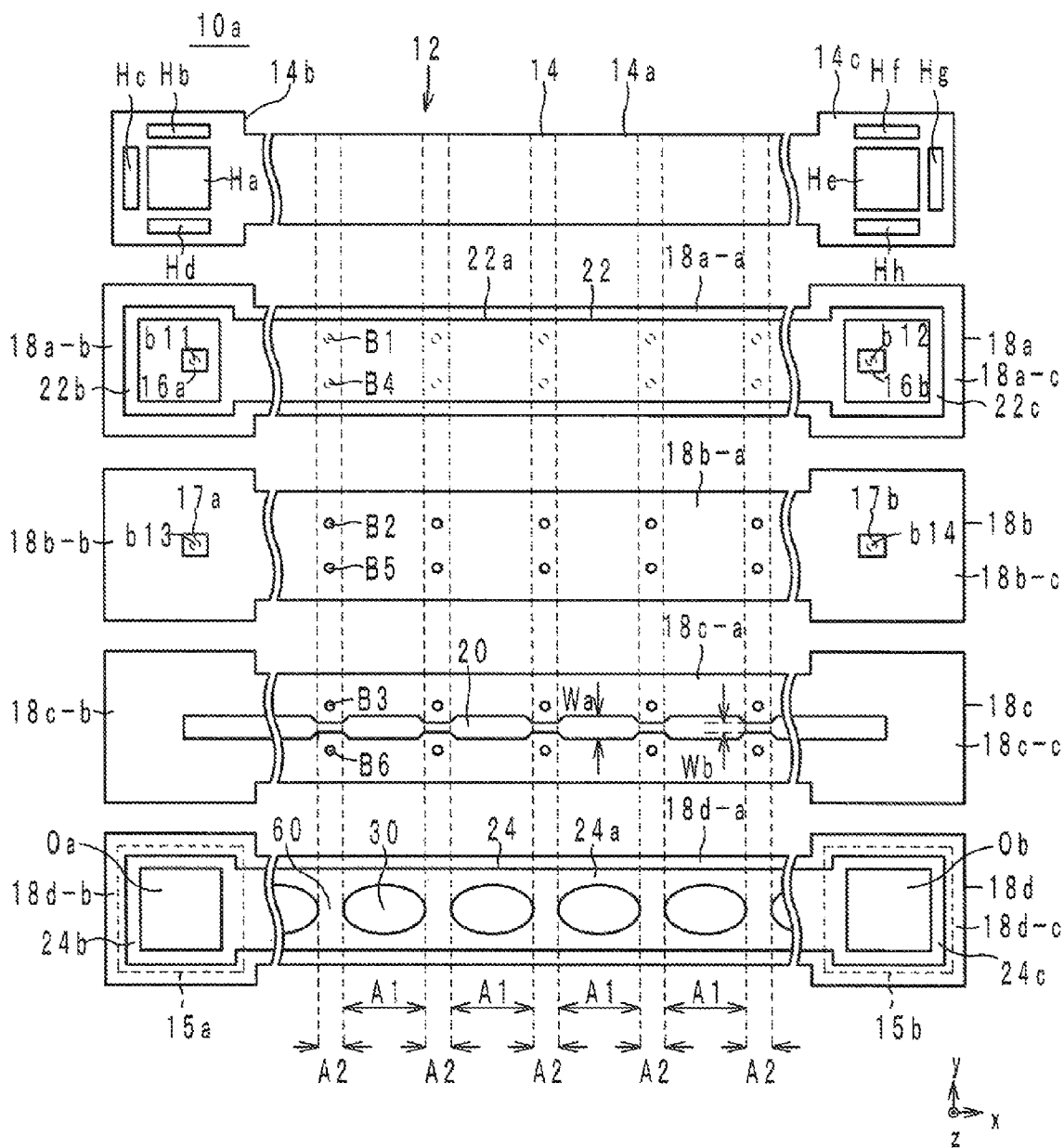


FIG. 10

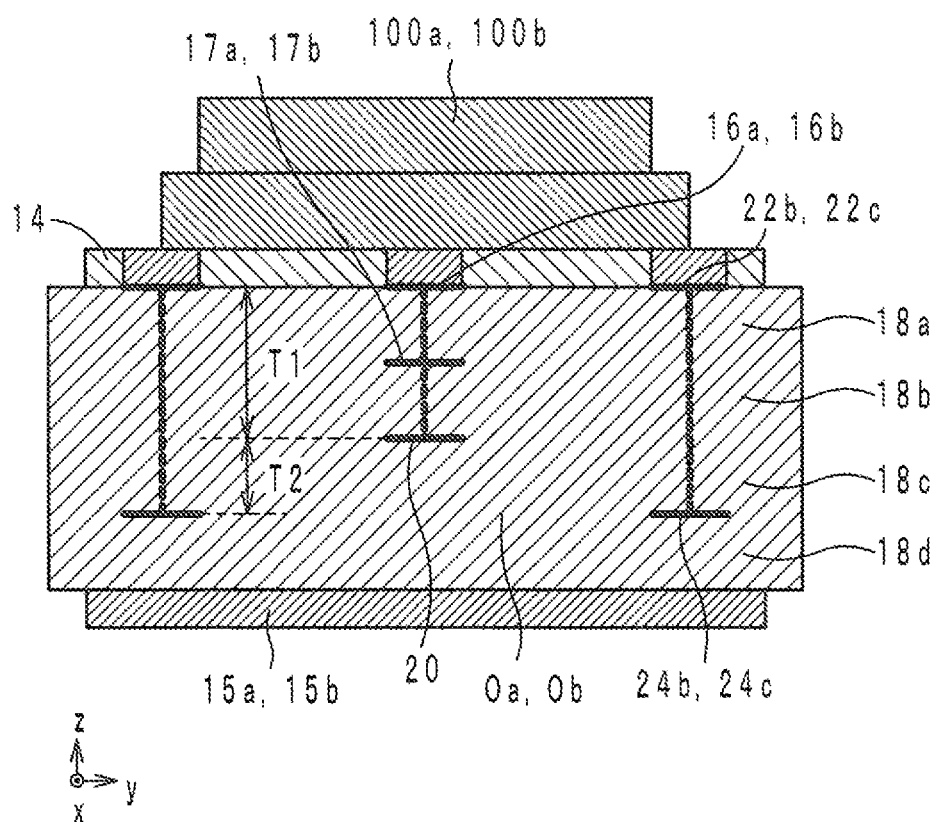


FIG. 11

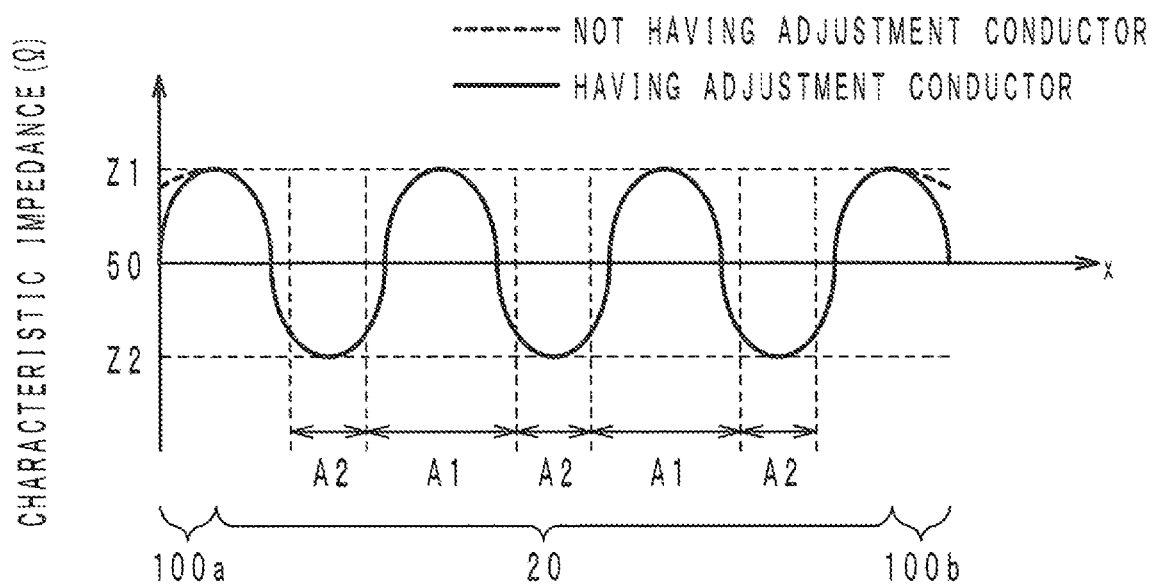


FIG. 12

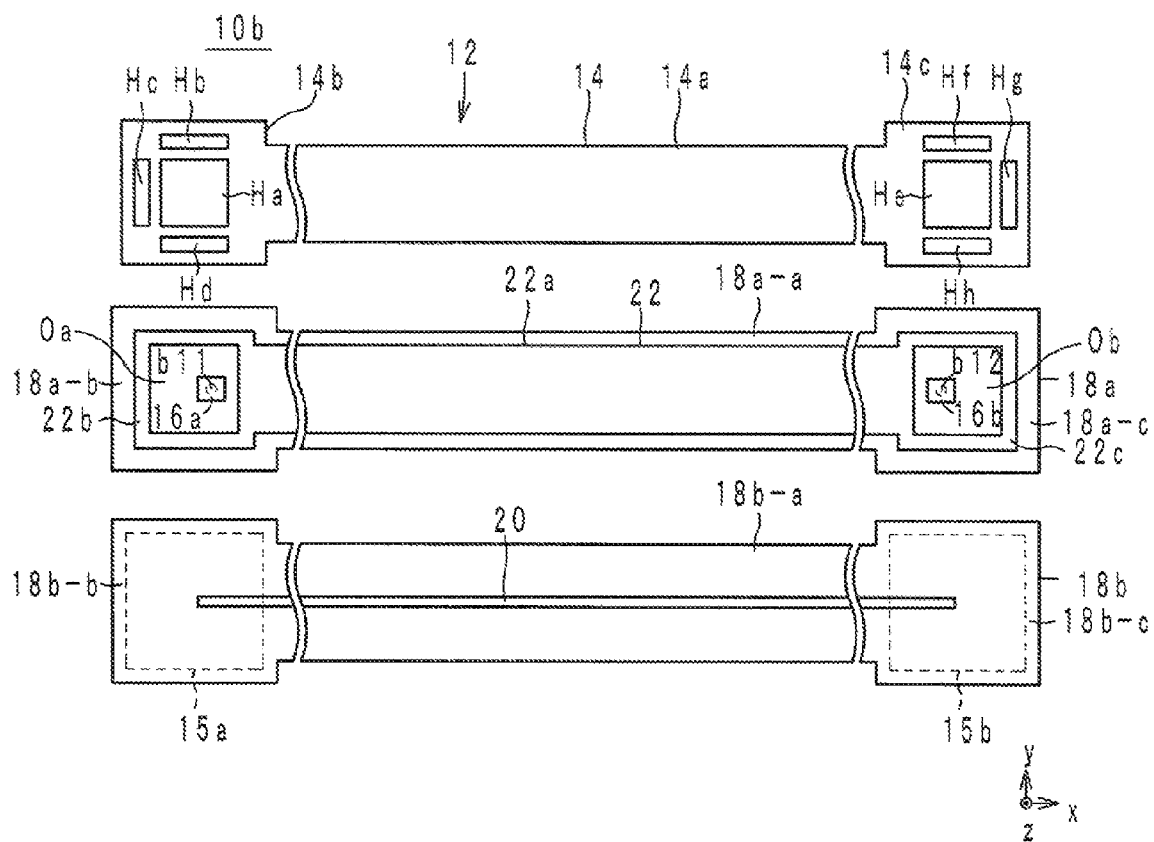


FIG. 13A

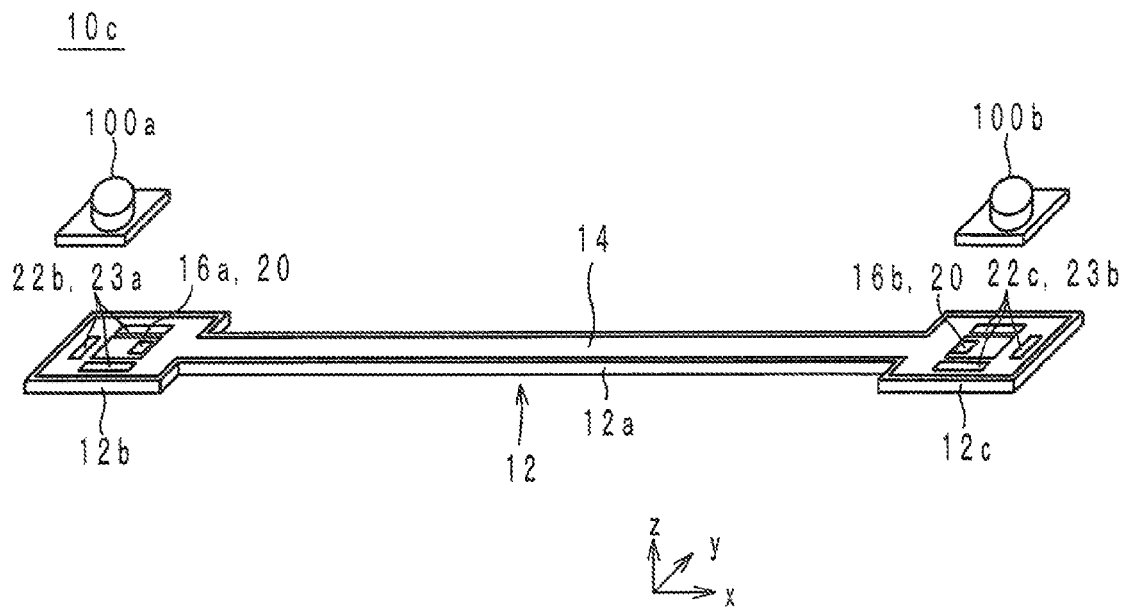


FIG. 13B

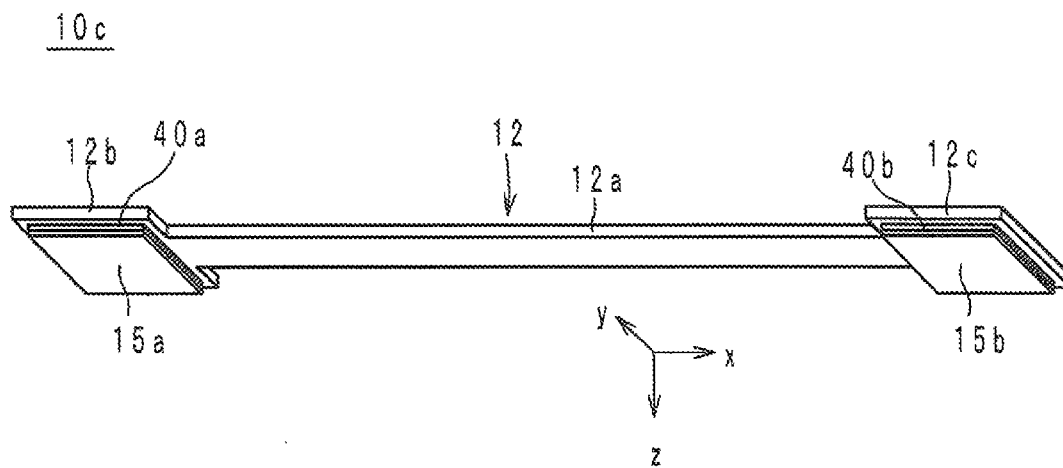


FIG. 14A

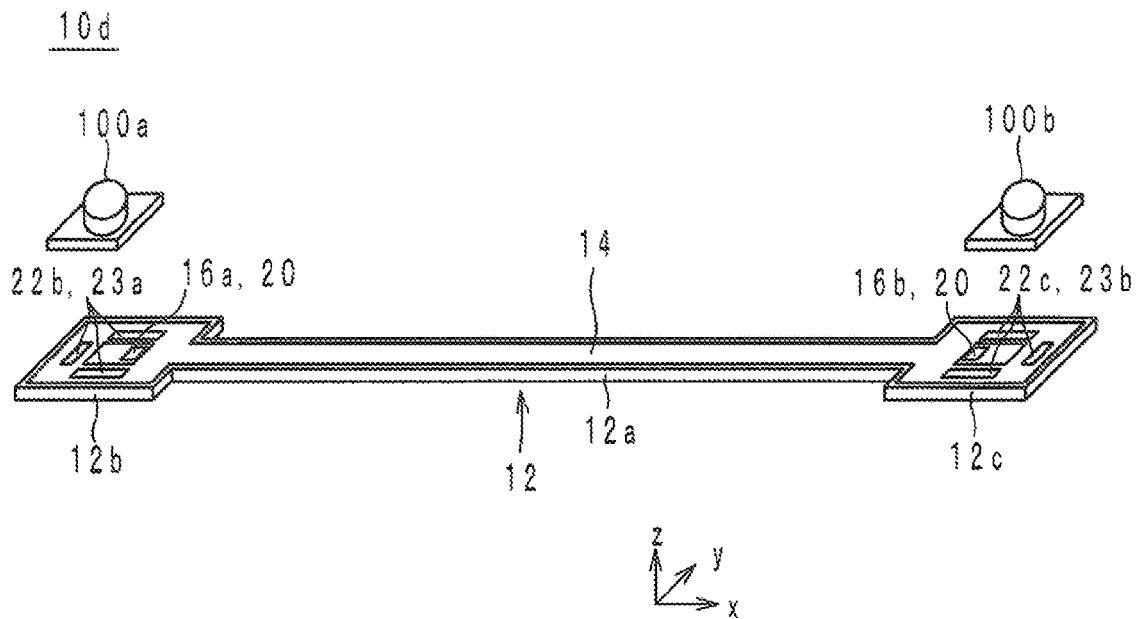


FIG. 14B

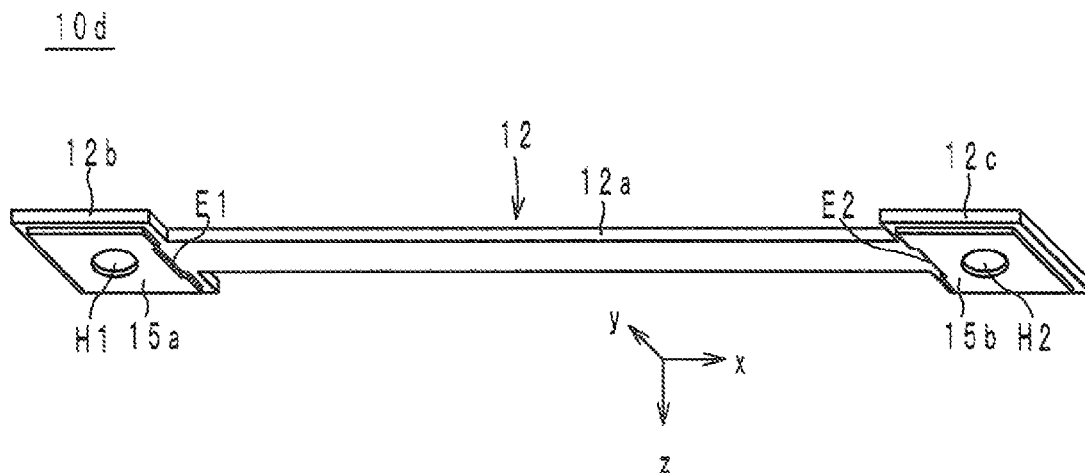


FIG. 15

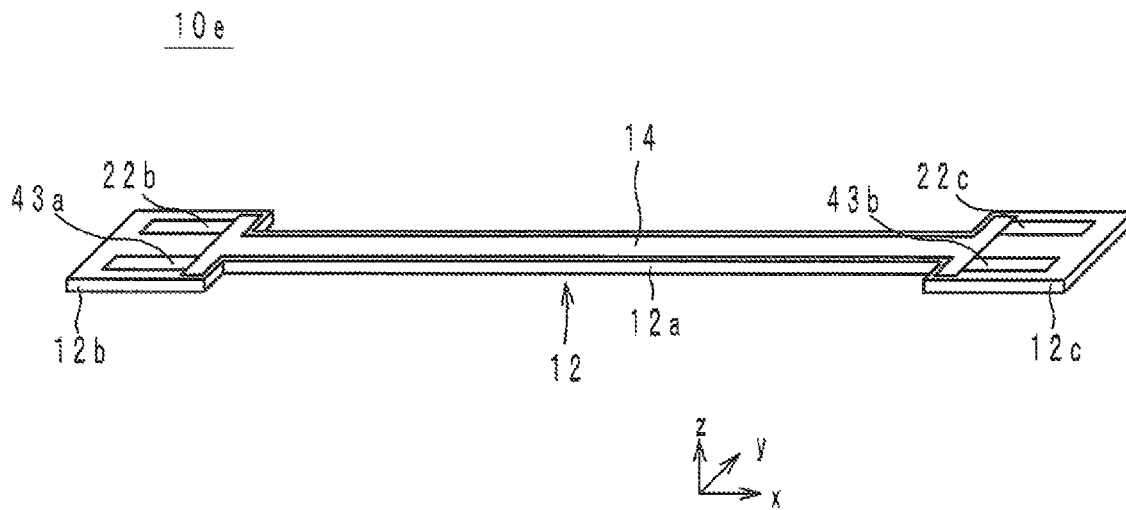


FIG. 16

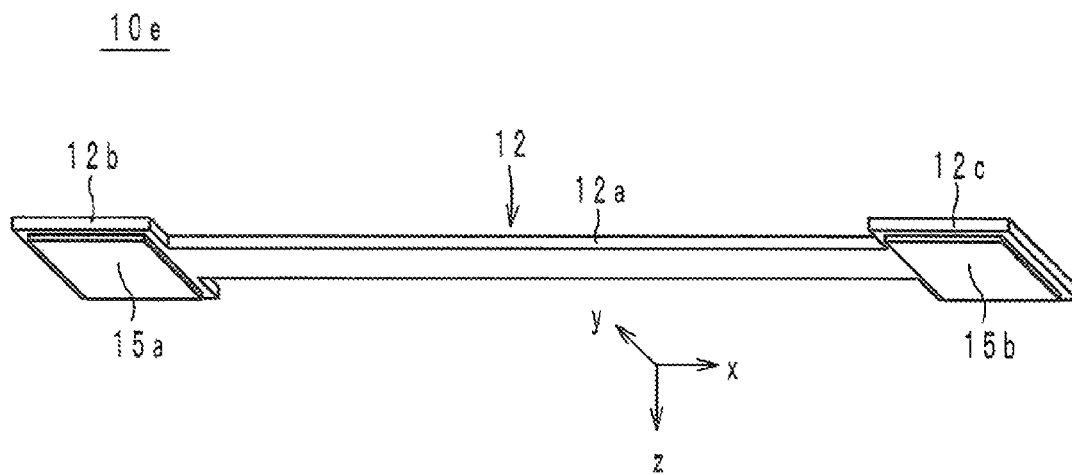




FIG. 17

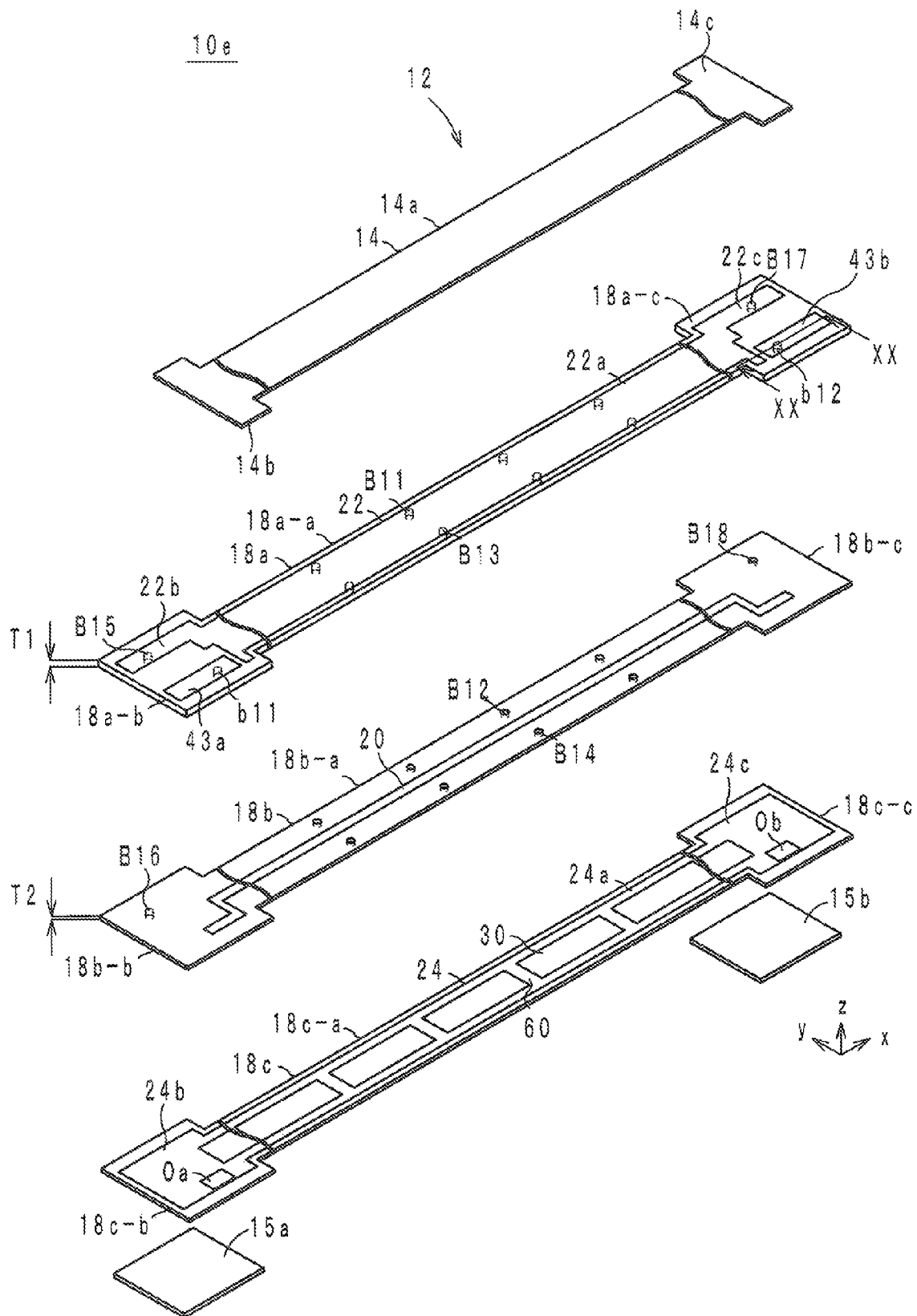


FIG. 18

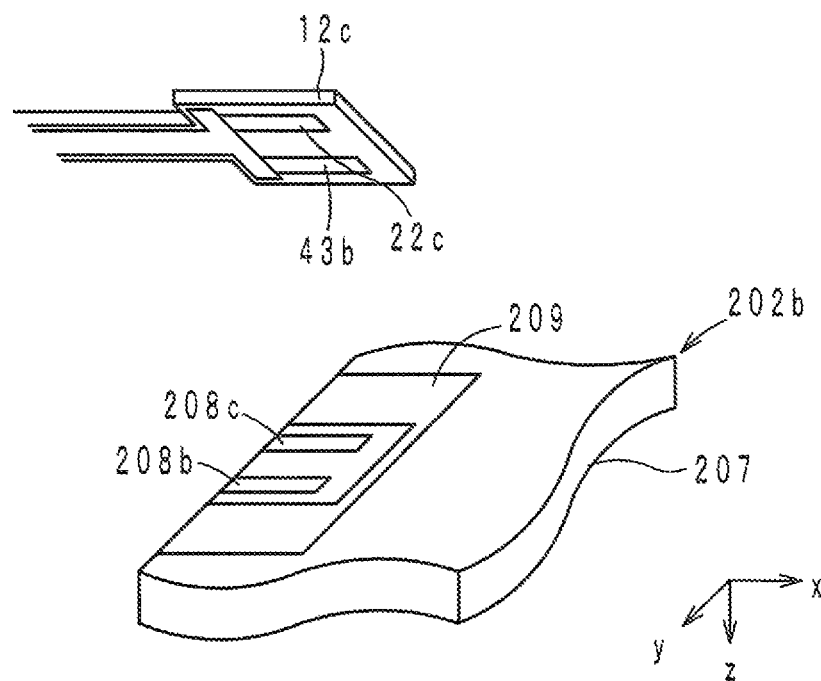
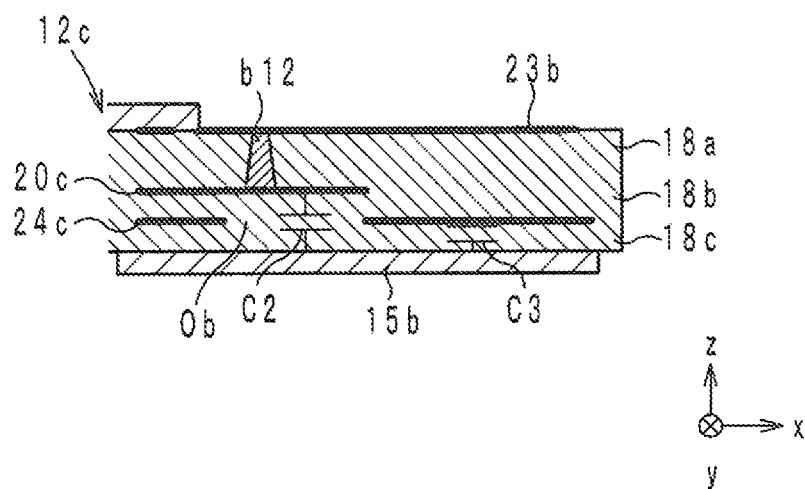




FIG. 20



1

# HIGH-FREQUENCY SIGNAL TRANSMISSION LINE AND ELECTRONIC DEVICE

## BACKGROUND OF THE INVENTION

### 1. Field of the Invention

The present invention relates to a high-frequency signal transmission line and an electronic device, and more specifically relates to a high-frequency signal transmission line and an electronic device, in each of which a signal line is provided in a body including laminated insulator layers.

### 2. Description of the Related Art

As a high-frequency signal transmission line of the related art, a microstrip flexible substrate connection line has been known that is described in, for example, Japanese Unexamined Patent Application Publication No. 9-139610. In the microstrip flexible substrate connection line, microstrip lines are formed with sandwiching therebetween a thin flexible dielectric substrate. Such a microstrip flexible substrate connection line is thinner than a coaxial cable. Therefore, it is easy to dispose the microstrip flexible substrate connection line in a narrow space within a wireless communication terminal.

Incidentally, in a case where circuit substrates are connected to each other using the microstrip flexible substrate connection line described in Japanese Unexamined Patent Application Publication No. 9-139610, it may be considered that a coaxial connector receptacle described in, for example, Japanese Patent No. 3161281 is used. Specifically, the coaxial connector receptacle is mounted on one end of the microstrip flexible substrate connection line. In addition, the coaxial connector receptacle is attached to a coaxial connector plug provided in a circuit substrate, and hence, the microstrip flexible substrate connection line is connected to the circuit substrate. As a result, it becomes possible to easily connect the microstrip flexible substrate connection line to the circuit substrate.

However, in a case where the coaxial connector receptacle is applied to the microstrip flexible substrate connection line, there is a possibility that the characteristic impedance of a signal line is mismatched with respect to a predetermined characteristic impedance (for example,  $50\Omega$ ). In more detail, the coaxial connector receptacle is configured by a plurality of parts. Therefore, stray capacitance or parasitic inductance easily occurs in the coaxial connector receptacle, and the characteristic impedance of the coaxial connector receptacle is easily mismatched with respect to the predetermined characteristic impedance. Furthermore, there is a possibility that coaxial connector receptacles having various structures are mounted on the microstrip flexible substrate connection line. Therefore, there is a possibility that a characteristic impedance varies with respect to each type of coaxial connector receptacle. As described above, if the characteristic impedance of the coaxial connector receptacle is mismatched with respect to the predetermined characteristic impedance, the reflection of a high-frequency signal occurs in the coaxial connector receptacle.

In addition, even in a case where the coaxial connector receptacle is not used, there is a possibility that the characteristic impedance of the signal line is mismatched with respect to the predetermined characteristic impedance, due to the following reason. In a case where the coaxial connector receptacle is not used, an external electrode, connected to the signal line, is provided on the surface of an end portion of the microstrip flexible substrate connection line. In addition, in a case where the microstrip flexible substrate connection line is

2

connected to a circuit substrate, the external electrode is connected to a land electrode in the circuit substrate by a solder or the like. In this case, in the vicinity of the external electrode, a conductor shape or the like is different compared with the forming region of the signal line, and the characteristic impedance of an external electrode portion is different from the forming region of the signal line in some cases. As a result, there is a possibility that the characteristic impedance of the signal line is mismatched with respect to the predetermined characteristic impedance.

## SUMMARY OF THE INVENTION

Accordingly, preferred embodiments of the present invention provide a high-frequency signal transmission line and an electronic device that significantly reduce or prevent mismatching of a characteristic impedance in a connector with respect to a predetermined characteristic impedance.

According to various preferred embodiments of the present invention, it is possible to obtain a high-frequency signal transmission line and an electronic device that significantly reduce or prevent mismatching of a characteristic impedance in a connector with respect to a predetermined characteristic impedance.

The above and other elements, features, steps, characteristics and advantages of the present invention will become more apparent from the following detailed description of the preferred embodiments with reference to the attached drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1A and 1B are appearance perspective views of a high-frequency signal transmission line according to a first preferred embodiment of the present invention.

FIG. 2 is an exploded view of a dielectric body of the high-frequency signal transmission line according to the first preferred embodiment of the present invention.

FIG. 3 is a cross-sectional structural view of the high-frequency signal transmission line according to the first preferred embodiment of the present invention.

FIGS. 4A and 4B are an appearance perspective view and a cross-sectional structural view of a connector for a high-frequency signal transmission line.

FIGS. 5A and 5B are diagrams of an electronic device in which a high-frequency signal transmission line is used, in a planar view from a y-axis direction and a z-axis direction.

FIG. 6 is a graph illustrating a characteristic impedance of the high-frequency signal transmission line according to the first preferred embodiment of the present invention.

FIG. 7 is an equivalent circuit diagram of a high-frequency signal transmission line.

FIG. 8 is a cross-sectional structural view of a high-frequency signal transmission line.

FIG. 9 is an exploded view of a dielectric body of a high-frequency signal transmission line according to a second preferred embodiment of the present invention.

FIG. 10 is a cross-sectional structural view of the high-frequency signal transmission line according to the second preferred embodiment of the present invention.

FIG. 11 is a graph illustrating a characteristic impedance of the high-frequency signal transmission line according to the second preferred embodiment of the present invention.

FIG. 12 is an exploded view of a dielectric body of a high-frequency signal transmission line according to a third preferred embodiment of the present invention.

FIGS. 13A and 13B are appearance perspective views of a high-frequency signal transmission line according to a first example of a modification of a preferred embodiment of the present invention.

FIGS. 14A and 14B are appearance perspective views of a high-frequency signal transmission line according to a second example of a modification of a preferred embodiment of the present invention.

FIG. 15 is an appearance perspective view of a high-frequency signal transmission line according to a fourth preferred embodiment of the present invention.

FIG. 16 is an appearance perspective view of the high-frequency signal transmission line according to the fourth preferred embodiment of the present invention.

FIG. 17 is an exploded perspective view of a dielectric body of the high-frequency signal transmission line in FIG. 15.

FIG. 18 is a perspective view of a connection portion between a high-frequency signal transmission line and a circuit substrate.

FIG. 19 is a cross-sectional structural view of a connection portion between a high-frequency signal transmission line and a circuit substrate.

FIG. 20 is a cross-sectional structural view of the high-frequency signal transmission line taken along a line XX-XX in FIG. 17.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, high-frequency signal transmission lines and an electronic device according to preferred embodiments of the present invention will be described with reference to drawings.

##### First Preferred Embodiment

Hereinafter, the configuration of a high-frequency signal transmission line according to a first preferred embodiment of the present invention will be described with reference to drawings. FIGS. 1A and 1B are appearance perspective views of a high-frequency signal transmission line 10 according to the first preferred embodiment. FIG. 2 is a exploded view of the dielectric body 12 of the high-frequency signal transmission line 10 according to the first preferred embodiment. FIG. 3 is a cross-sectional structural view of the high-frequency signal transmission line 10 according to the first preferred embodiment. FIGS. 4A and 4B are appearance perspective view and the cross-sectional structural view of a connector 100b for the high-frequency signal transmission line 10. In FIGS. 1A and 1B to FIGS. 4A and 4B, the lamination direction of the high-frequency signal transmission line 10 is defined as a z-axis direction. In addition, the longitudinal direction of the high-frequency signal transmission line 10 is defined as an x-axis direction, and a direction perpendicular to the x-axis direction and the z-axis direction is defined as a y-axis direction.

The high-frequency signal transmission line 10 is used for, for example, connecting two high-frequency circuits within an electronic device such as a cellular phone. As illustrated in FIGS. 1A and 1B to FIG. 3, the high-frequency signal transmission line 10 includes the dielectric body 12, adjustment plates 15 (15a and 15b) (adjustment conductors), a signal line 20, terminal portions 23 (23a and 23b), a ground conductor 25, via hole conductors b1 and b2, and connectors 100a and 100b.

In a planar view from the z-axis direction, the dielectric body 12 extends in the x-axis direction, and includes a line portion 12a and connection portions 12b and 12c. The dielectric body 12 is a laminated body preferably including a protective layer 14 and dielectric sheets (insulator layers) 18 (18a and 18b), illustrated in FIG. 2, being laminated in this order from a positive direction side in the z-axis direction to a negative direction side therein. In what follows, the main surface of the dielectric body 12 on the positive direction side in the z-axis direction is referred to as a front surface, and the main surface of the dielectric body 12 on the negative direction side in the z-axis direction is referred to as a back surface.

The line portion 12a extends in the x-axis direction. The connection portions 12b and 12c are connected to an end portion of the line portion 12a on a negative direction side in the x-axis direction and an end portion of the line portion 12a on a positive direction side in the x-axis direction, respectively, and have respective rectangular or substantially rectangular shapes. The widths of the connection portions 12b and 12c in the y-axis direction are wider than the width of the line portion 12a in the y-axis direction.

The dielectric sheet 18 extends in the x-axis direction, and preferably has the same or substantially the same shape as the dielectric body 12 in a planar view from the z-axis direction. The dielectric sheet 18 is preferably made of a thermoplastic resin having flexibility, such as polyimide or liquid crystalline polymer. The thickness of the dielectric sheet 18 after lamination preferably ranges, for example, from about 50  $\mu\text{m}$  to about 200  $\mu\text{m}$ . Hereinafter, the main surface of the dielectric sheet 18 on the positive direction side in the z-axis direction is referred to as a front surface, and the main surface of the dielectric sheet 18 on the negative direction side in the z-axis direction is referred to as a back surface.

In addition, the dielectric sheet 18a includes a line portion 18a-a and connection portions 18a-b and 18a-c. The dielectric sheet 18b includes a line portion 18b-a and connection portions 18b-b and 18b-c. The line portions 18a-a and 18b-a configure the line portion 12a. The connection portions 18a-b and 18b-b configure the connection portion 12b. The connection portions 18a-c and 18b-c configure the connection portion 12c.

As illustrated in FIG. 2, the signal line 20 is a linear conductor provided within the dielectric body 12, and extends in the x-axis direction on the front surface of the dielectric sheet 18a. Both the respective end portions of the signal line 20 are located in the centers of the connection portions 18a-b and 18a-c in a planar view from the z-axis direction. The signal line 20 is manufactured using a metal material whose specific resistance is small and whose main component is silver or copper. In addition, both end portions of the signal line 20 preferably are gold-plated.

As illustrated in FIG. 2, the ground conductor 25 (a first ground conductor) is provided within the dielectric body 12 on the negative direction side in the z-axis direction, compared with the signal line 20 (in other words, on the back surface side of the dielectric body 12, compared with the signal line 20), and in more detail, provided on the front surface of the dielectric sheet 18b. The ground conductor 25 extends in the x-axis direction along the signal line 20 on the front surface of the dielectric sheet 18b, and faces the signal line 20 across the dielectric sheet 18a, as illustrated in FIG. 2. As a result, the signal line 20 and the ground conductor 25 form a microstrip line structure. The ground conductor 25 is manufactured using a metal material whose specific resistance is small and whose main component is silver or copper.

In addition, the ground conductor 25 includes a main conductor 25a and terminal conductors 25b and 25c. The main

5

conductor **25a** is provided on the front surface of the line portion **18b-a**, and extends in the x-axis direction.

The terminal conductor **25b** is provided on the front surface of the connection portion **18b-b**, and defines a rectangular or substantially rectangular ring surrounding the center of the connection portion **18b-b**. As a result, in the ground conductor **25**, a conductor-missing portion **Oa** is provided in a region surrounded by the terminal conductor **25b**. As a result, an end portion of the signal line **20** on the negative direction side in the x-axis direction is located within the conductor-missing portion **Oa** in a planar view from the z-axis direction. The terminal conductor **25b** is connected to an end portion of the main conductor **25a** on the negative direction side in the x-axis direction.

The terminal conductor **25c** is provided on the front surface of the connection portion **18b-c**, and has a ring-shaped rectangular or substantially rectangular shape surrounding the center of the connection portion **18b-c**. As a result, in the ground conductor **25**, a conductor-missing portion **Ob** is provided in a region surrounded by the terminal conductor **25c**. As a result, an end portion of the signal line **20** on the positive direction side in the x-axis direction is located within the conductor-missing portion **Ob** in a planar view from the z-axis direction. The terminal conductor **25c** is connected to an end portion of the main conductor **25a** on the positive direction side in the x-axis direction.

The terminal conductor **23a** is provided on the front surface of the connection portion **18a-b**, and has an angular U-shape surrounding the center of the connection portion **18a-b** (in other words, an end portion of the signal line **20** on the negative direction side in the x-axis direction). The terminal conductor **23a** has a shape that is open toward the positive direction side in the x-axis direction. In addition, in a planar view from the z-axis direction, the terminal conductor **23a** overlaps with the terminal conductor **25b**.

The terminal conductor **23b** is provided on the front surface of the connection portion **18a-c**, and has an angular U-shape surrounding the center of the connection portion **18a-c** (in other words, an end portion of the signal line **20** on the positive direction side in the x-axis direction). The terminal conductor **23b** has a shape that is open toward the negative direction side in the x-axis direction. In addition, in a planar view from the z-axis direction, the terminal conductor **23b** overlaps with the terminal conductor **25c**.

The via hole conductor **b1** penetrates the connection portion **18a-b** of the dielectric sheet **18a** in the z-axis direction. The via hole conductor **b1** connects the terminal conductor **23a** and the terminal conductor **25b** to each other. The via hole conductor **b2** penetrates the connection portion **18a-c** of the dielectric sheet **18a** in the z-axis direction. The via hole conductor **b2** connects the terminal conductor **23b** and the terminal conductor **25c** to each other.

The protective layer **14** covers substantially the entire surface of the front surface of the dielectric sheet **18a**. As a result, the protective layer **14** covers the signal line **20** and the terminal conductors **23a** and **23b**. The protective layer **14** is made of, for example, a flexible resin such as a resist material.

In addition, as illustrated in FIG. 2, the protective layer **14** includes a line portion **14a** and connection portions **14b** and **14c**. The line portion **14a** covers the signal line **20** by covering the entire surface of the front surface of the line portion **18a-a**.

The connection portion **14b** is connected to an end portion of the line portion **14a** on the negative direction side in the x-axis direction, and covers the front surface of the connection portion **18a-b**. In this regard, however, in the connection portion **14b**, openings **Ha** to **Hd** are provided. The opening **Ha** is a rectangular or substantially rectangular opening provided

6

at substantially the center of the connection portion **14b**. An end portion of the signal line **20** on the negative direction side in the x-axis direction is exposed to the outside through the opening **Ha**, and hence, functions as an external terminal. In addition, the opening **Hb** is a rectangular or substantially rectangular opening provided on the positive direction side of the opening **Ha** in the y-axis direction. The opening **Hc** is a rectangular or substantially rectangular opening provided on the negative direction side of the opening **Ha** in the x-axis direction. The opening **Hd** is a rectangular or substantially rectangular opening provided on the negative direction side of the opening **Ha** in the y-axis direction. The terminal conductor **23a** is exposed to the outside through the openings **Hb** to **Hd**, and hence, functions as an external terminal.

The connection portion **14c** is connected to an end portion of the line portion **14a** on the positive direction side in the x-axis direction, and covers the front surface of the connection portion **18a-c**. In this regard, however, in the connection portion **14c**, openings **He** to **Hh** are provided. The opening **He** is a rectangular or substantially rectangular opening provided at substantially the center of the connection portion **14c**. An end portion of the signal line **20** on the positive direction side in the x-axis direction is exposed to the outside through the opening **He**, and hence, functions as an external terminal. In addition, the opening **Hf** is a rectangular or substantially rectangular opening provided on the positive direction side of the opening **He** in the y-axis direction. The opening **Hg** is a rectangular or substantially rectangular opening provided on the positive direction side of the opening **He** in the x-axis direction. The opening **Hh** is a rectangular or substantially rectangular opening provided on the negative direction side of the opening **He** in the y-axis direction. The terminal conductor **23b** is exposed to the outside through the openings **Hf** to **Hh**, and hence, functions as an external terminal.

The adjustment plate **15a** is provided on the back surface of the connection portion **12b** of the dielectric body **12** (in other words, the back surface of the connection portion **18b-b** of the dielectric sheet **18b**), and a rectangular or substantially rectangular metal plate overlapping with at least a portion of the conductor-missing portion **Oa** in a planar view from the z-axis direction. Furthermore, the adjustment plate **15a** is not electrically connected to any one of the signal line **20** and the ground conductor **25**, and is maintained at a floating potential. In more detail, the adjustment plate **15a** overlaps with the whole of the conductor-missing portion **Oa** in a planar view from the z-axis direction, and hence, overlaps with an end portion of the signal line **20** on the negative direction side in the x-axis direction. As a result, capacitance is generated between the adjustment plate **15a** and an end portion of the signal line **20** on the negative direction side in the x-axis direction. Furthermore, the adjustment plate **15a** protrudes out of the conductor-missing portion **Oa**, and hence, overlaps with the terminal conductor **25b** of the ground conductor **25** in a planar view from the z-axis direction. As a result, capacitance is generated between the adjustment plate **15a** and the terminal conductor **25b** of the ground conductor **25**.

The adjustment plate **15b** is provided on the back surface of the connection portion **12c** of the dielectric body **12** (in other words, the back surface of the connection portion **18b-c** of the dielectric sheet **18b**), and a rectangular or substantially rectangular metal plate overlapping with at least a portion of the conductor-missing portion **Ob** in a planar view from the z-axis direction. Furthermore, the adjustment plate **15b** is not electrically connected to any one of the signal line **20** and the ground conductor **25**, and is maintained at a floating potential. In more detail, the adjustment plate **15b** overlaps with the whole of the conductor-missing portion **Ob** in a planar view

from the z-axis direction, and hence, overlaps with an end portion of the signal line **20** on the positive direction side in the x-axis direction. As a result, capacitance is generated between the adjustment plate **15b** and an end portion of the signal line **20** on the positive direction side in the x-axis direction. Furthermore, the adjustment plate **15b** protrudes out of the conductor-missing portion **Ob**, and hence, overlaps with the terminal conductor **25c** of the ground conductor **25** in a planar view from the z-axis direction. As a result, capacitance is generated between the adjustment plate **15b** and the terminal conductor **25c** of the ground conductor **25**. The adjustment plates **15a** and **15b** are configured by, for example, copper plates or SUS plates.

The connectors **100a** and **100b** are mounted on the front surfaces of the connection portions **12b** and **12c**, respectively, and individually electrically connected to the signal line **20** and the ground conductor **25**. Since the configurations of the connectors **100a** and **100b** are equal to each other, the configuration of the connector **100b** will be cited as an example and described, hereinafter.

As illustrated in FIGS. 1A and 1B and FIGS. 4A and 4B, the connector **100b** includes a connector main body **102**, external terminals **104** and **106**, a center conductor **108**, and an external conductor **110**. The connector main body **102** has a shape in which a cylinder is connected to a rectangular or substantially rectangular plate, and is manufactured using an insulating material such as a resin.

In the surface of the plate of the connector main body **102** on the negative direction side in the z-axis direction, the external terminal **104** is provided in a position in which to face an end portion of the signal line **20** on the positive direction side in the x-axis direction. In the surface of the plate of the connector main body **102** on the negative direction side in the z-axis direction, the external terminal **106** is provided in a position to correspond to the terminal conductor **23b** exposed through the openings **Hf** to **Hh**.

The center conductor **108** is provided in the center of the cylinder of the connector main body **102**, and connected to the external terminal **104**. The center conductor **108** is a signal terminal from which a high-frequency signal is input or output. The external conductor **110** is provided on the inner peripheral surface of the cylinder of the connector main body **102**, and connected to the external terminal **106**. The external conductor **110** is a ground terminal maintained at a ground potential.

The connector **100b** configured in such a way as described above is mounted on the front surface of the connection portion **12c** so that the external terminal **104** is connected to an end portion of the signal line **20** on the positive direction side in the x-axis direction and the external terminal **106** is connected to the terminal conductor **23b**. As a result, the signal line **20** is electrically connected to the center conductor **108**. In addition, the ground conductor **25** is electrically connected to the external conductor **110**.

In addition, in a planar view from the z-axis direction, the connector **100b** overlaps with the conductor-missing portion **Ob** provided in the terminal conductor **25c** of the ground conductor **25**, as illustrated in FIG. 3. In this regard, however, it is not necessary for the connector **100b** and the conductor-missing portion **Ob** to correspondingly overlap with each other in a planar view from the z-axis direction. Therefore, it is only necessary for the conductor-missing portion **Ob** to be provided because no conductor is provided in at least a portion of a region overlapping with the connector **100b**, in a planar view from the z-axis direction. As illustrated in FIG. 3, in the high-frequency signal transmission line **10**, the connec-

tor **100b** protrudes out of the conductor-missing portion **Ob** in a planar view from the z-axis direction.

The high-frequency signal transmission line **10** is used in such a way as described below. FIGS. 5A and 5B are the diagrams of an electronic device **200** in which the high-frequency signal transmission line **10** is used, in a planar view from the y-axis direction and the z-axis direction.

The electronic device **200** includes the high-frequency signal transmission line **10**, circuit substrates **202a** and **202b**, receptacles **204a** and **204b**, a battery pack (metallic body) **206**, and a housing **210**.

The housing **210** contains the high-frequency signal transmission line **10**, the circuit substrates **202a** and **202b**, the receptacles **204a** and **204b**, and the battery pack (metallic body) **206**. In the circuit substrate **202a**, for example, a transmitting circuit or receiving circuit including an antenna is provided. In the circuit substrate **202b**, for example, a feed circuit is provided. The battery pack **206** is, for example, a lithium-ion secondary battery, and has a structure in which the surface thereof is covered by a metal cover. The circuit substrate **202a**, the battery pack **206**, and the circuit substrate **202b** are arranged in this order from the negative direction side to the positive direction side in the x-axis direction.

The receptacles **204a** and **204b** are provided on the main surfaces of the circuit substrates **202a** and **202b** on the negative direction side in the z-axis direction, respectively. The connectors **100a** and **100b** are connected to the receptacles **204a** and **204b**, respectively. In other words, through the front surface of the connection portion **12b**, the signal line **20** and the circuit substrate **202a** are electrically connected to each other. Through the front surface of the connection portion **12c**, the signal line **20** and the circuit substrate **202b** are electrically connected to each other. As a result, through the receptacles **204a** and **204b**, a high-frequency signal, which has the frequency of, for example, 2 GHz and is transmitted between the circuit substrates **202a** and **202b**, is applied to the center conductors **108** of the connectors **100a** and **100b**. In addition, through the circuit substrates **202a** and **202b** and the receptacles **204a** and **204b**, the external conductors **110** of the connectors **100a** and **100b** are maintained at a ground potential. As a result, the high-frequency signal transmission line **10** establishes electrical connection between the circuit substrates **202a** and **202b**.

Here, the front surface of the dielectric body **12** (more correctly, the protective layer **14**) is in contact with the battery pack **206**. In addition, the front surface of the dielectric body **12** and the battery pack **206** are fixed to each other by an adhesive or the like.

Hereinafter, a non-limiting example of a manufacturing method for the high-frequency signal transmission line **10** will be described with reference to FIG. 2. While, hereinafter, a case where one high-frequency signal transmission line **10** is manufactured will be cited as an example and described, actually large-sized dielectric sheets are laminated and cut, and hence, a plurality of high-frequency signal transmission lines **10** are simultaneously manufactured.

First, the dielectric sheet **18** made of a thermoplastic resin is prepared where copper foil is formed on the entire surface of the front surface thereof. The surface of the copper foil of the dielectric sheet **18** is smoothed by being subjected to, for example, zinc plating used for antirust. The thickness of the copper foil preferably ranges from about 10  $\mu\text{m}$  to about 20  $\mu\text{m}$ .

Next, using a photolithography process, the signal line **20** and the terminal conductors **23a** and **23b**, illustrated in FIG. 2, are formed on the front surface of the dielectric sheet **18a**. Specifically, on the copper foil of the dielectric sheet **18a**,



resists are printed that have the same shapes as the signal line 20 and the terminal conductors 23a and 23b, illustrated in FIG. 2. In addition, by performing an etching processing on the copper foil, the copper foil of a portion not covered by the resist is removed. After that, the resist is removed. As a result, such a signal line 20 and terminal conductors 23a and 23b as illustrated in FIG. 2 are formed on the front surface of the dielectric sheet 18a.

Next, using a photolithography process, the ground conductor 25 illustrated in FIG. 2 is formed on the front surface of the dielectric sheet 18b. In addition, since the photolithography process here is preferably the same as the photolithography process in a case where the signal line 20 and the terminal conductors 23a and 23b are formed, the description thereof will be omitted.

Next, positions in which to form the via hole conductors b1 and b2 in the dielectric sheet 18a are subjected to a laser beam from the back surface side, and through holes are formed. After that, the through holes formed in the dielectric sheet 18a are filled with conductive pastes.

Next, the dielectric sheets 18a and 18b are stacked in this order from the positive direction side to the negative direction side in the z-axis direction. In addition, by applying heat and pressure to the dielectric sheets 18a and 18b from the positive direction side and the negative direction side in the z-axis direction, the dielectric sheets 18a and 18b are softened to be pressure-bonded and integrated and the conductive pastes with which the through holes have been filled are solidified to form the via hole conductors b1 and b2 illustrated in FIG. 2. In addition, the individual dielectric sheets 18 may also be integrated using an adhesive such as an epoxy based resin in place of the thermocompression bonding. In addition, through holes may also be formed after the dielectric sheets 18 have been integrated, and by filling the through holes with conductive pastes or forming plated films in the through holes, the via hole conductors b1 and b2 may also be formed. In addition, in the via hole conductors b1 and b2, it is not necessary for the through holes to be completely filled with conductors, and the via hole conductors b1 and b2 may also be formed by, for example, forming conductors only along the inner peripheral surfaces of the through holes.

Next, by applying a resin (resist) paste, the protective layer 14 is formed on the dielectric sheet 18a.

Finally, using an adhesive or the like, the adjustment plates 15a and 15b are stuck to the back surfaces of the connection portions 12b and 12c. As a result, the high-frequency signal transmission line 10 illustrated in FIGS. 1A and 1B is obtained.

According to the high-frequency signal transmission line 10 configured in such a way as described above, it is possible to significantly reduce or prevent the mismatching of characteristic impedances in the connectors 100a and 100b with respect to predetermined characteristic impedances. FIG. 6 is a graph illustrating the characteristic impedance of the high-frequency signal transmission line 10 according to the first preferred embodiment. A vertical axis indicates the characteristic impedance, and a horizontal axis indicates an x-axis. A solid line in FIG. 6 indicates the characteristic impedance of the high-frequency signal transmission line 10, and a dotted line in FIG. 6 indicates the characteristic impedance of a high-frequency signal transmission line according to a comparative example. In the high-frequency signal transmission line according to the comparative example, the adjustment plates 15a and 15b are not provided. FIG. 7 is the equivalent circuit diagram of the high-frequency signal transmission line 10. FIG. 8 is the cross-sectional structural view of the high-frequency signal transmission line 10.

In the high-frequency signal transmission line according to the comparative example, when the connectors 100a and 100b have been mounted on both end portions of the dielectric body 12, characteristic impedances in the connectors 100a and 100b are mismatched with respect to the predetermined characteristic impedance (e.g., about 50Ω). Here, the connectors 100a and 100b have been designed so that the characteristic impedances of the connectors 100a and 100b become slightly higher than the predetermined characteristic impedance.

Therefore, in the high-frequency signal transmission line 10, the adjustment plates 15a and 15b are individually provided on the back surface of the dielectric body 12, and overlap with at least portions of the conductor-missing portions Oa and Ob, respectively, in a planar view from the z-axis direction. As a result, as illustrated in FIG. 7 and FIG. 8, capacitances C2 turn out to be generated between the adjustment plates 15a and 15b and the end portions of the signal line 20. Furthermore, capacitances C3 turn out to be generated between the adjustment plates 15a and 15b and the terminal conductors 25b and 25c of the ground conductor 25. In other words, between the signal line 20 and the ground conductor 25, the capacitances C2 and C3 are connected in series.

Here, when the capacitances C2 and C3 have been connected in series, the combined capacitance Ct of the capacitances C2 and C3 becomes a minute value. Accordingly, the minute combined capacitances Ct are generated in the connectors 100a and 100b, and it becomes possible to slightly reduce the characteristic impedances of the connectors 100a and 100b. In other words, it is possible to finely adjust the characteristic impedances of the connectors 100a and 100b. As a result of the above features, in the high-frequency signal transmission line 10, by providing the conductor-missing portions Oa and Ob and the adjustment plates 15a and 15b, it is possible to match the characteristic impedances of the connectors 100a and 100b to the predetermined characteristic impedance with a high degree of accuracy.

In addition, in a case where the connectors 100a and 100b are attached to the receptacles 204a and 204b, forces are applied to the connection portions 12b and 12c. Therefore, there is a possibility that the connection portions 12b and 12c are greatly deformed and damaged. Therefore, in the high-frequency signal transmission line 10, the adjustment plates 15a and 15b are provided in the connection portions 12b and 12c, the adjustment plates 15a and 15b being more rigid than the dielectric body 12. As a result, the large deformations of the connection portions 12b and 12c are significantly reduced or prevented, and the damages of the connection portions 12b and 12c are significantly reduced or prevented.

## Second Preferred Embodiment

Hereinafter, the configuration of a high-frequency signal transmission line according to a second preferred embodiment of the present invention will be described with reference to drawings. FIG. 9 is an exploded view of the dielectric body 12 of a high-frequency signal transmission line 10a according to the second preferred embodiment. FIG. 10 is a cross-sectional structural view of the high-frequency signal transmission line 10a according to the second preferred embodiment. In addition, as for the appearance perspective view of the high-frequency signal transmission line 10a, FIGS. 1A and 1B are incorporated.

As illustrated in FIGS. 1A and 1B and FIG. 9, the high-frequency signal transmission line 10a includes the dielectric body 12, external terminals 16 (16a and 16b), connection conductors 17 (17a and 17b), a signal line 20, ground con-

11

ductors **22** and **24**, via hole conductors **b11** to **b14** and **B1** to **B6**, and connectors **100a** and **100b**.

In a planar view from the z-axis direction, the dielectric body **12** extends in the x-axis direction, and includes a line portion **12a** and connection portions **12b** and **12c**. The dielectric body **12** is a laminated body configured by a protective layer **14** and dielectric sheets (insulator layers) **18** (**18a** to **18d**), illustrated in FIG. 2, being laminated in this order from the positive direction side in the z-axis direction to the negative direction side therein. In what follows, the main surface of the dielectric body **12** on a positive direction side in the z-axis direction is referred to as a front surface, and the main surface of the dielectric body **12** on a negative direction side in the z-axis direction is referred to as a back surface.

The line portion **12a** extends in the x-axis direction. The connection portions **12b** and **12c** are connected to an end portion of the line portion **12a** on a negative direction side in the x-axis direction and an end portion of the line portion **12a** on a positive direction side in the x-axis direction, respectively, and have respective rectangular or substantially rectangular shapes. The widths of the connection portions **12b** and **12c** in the y-axis direction are wider than the width of the line portion **12a** in the y-axis direction.

The dielectric sheet **18** extends in the x-axis direction, and preferably has the same or substantially the same shape as the dielectric body **12** in a planar view from the z-axis direction. The dielectric sheet **18** is configured by a thermoplastic resin having flexibility, such as polyimide or liquid crystalline polymer. The thickness of the dielectric sheet **18** after lamination preferably ranges, for example, from about 50  $\mu\text{m}$  to about 200  $\mu\text{m}$ . Hereinafter, the main surface of the dielectric sheet **18** on the positive direction side in the z-axis direction is referred to as a front surface, and the main surface of the dielectric sheet **18** on the negative direction side in the z-axis direction is referred to as a back surface.

In addition, the dielectric sheet **18a** includes a line portion **18a-a** and connection portions **18a-b** and **18a-c**. The dielectric sheet **18b** includes a line portion **18b-a** and connection portions **18b-b** and **18b-c**. The dielectric sheet **18c** includes a line portion **18c-a** and connection portions **18c-b** and **18c-c**. The dielectric sheet **18d** includes a line portion **18d-a** and connection portions **18d-b** and **18d-c**. The line portions **18a-a**, **18b-a**, **18c-a**, and **18d-a** configure the line portion **12a**. The connection portions **18a-b**, **18b-b**, **18c-b**, and **18d-b** configure the connection portion **12b**. The connection portions **18a-c**, **18b-c**, **18c-c**, and **18d-c** configure the connection portion **12c**.

As illustrated in FIGS. 1A and 1B and FIG. 9, the external terminal **16a** is a rectangular or substantially rectangular conductor provided on the vicinity of the center of the front surface of the connection portion **18a-b**. As illustrated in FIGS. 1A and 1B and FIG. 9, the external terminal **16b** is a rectangular or substantially rectangular conductor provided on the vicinity of the center of the front surface of the connection portion **18a-c**. The external terminals **16a** and **16b** are manufactured using metal materials whose specific resistances are small and whose main components are silver or copper. In addition, the surfaces of the external terminals **16a** and **16b** preferably are gold-plated.

As illustrated in FIGS. 1A and 1B and FIG. 9, the connection conductor **17a** is a rectangular or substantially rectangular conductor provided on the vicinity of the center of the front surface of the connection portion **18b-b**, and overlaps with the external terminal **16a** in a planar view from the z-axis direction. As illustrated in FIGS. 1A and 1B and FIG. 9, the connection conductor **17b** is a rectangular or substantially rectangular conductor provided on the vicinity of the center of the front surface of the connection portion **18b-c**, and over-

12

laps with the external terminal **16b** in a planar view from the z-axis direction. The connection conductors **17a** and **17b** are manufactured using metal materials whose specific resistances are small and whose main components are silver or copper.

As illustrated in FIG. 9, the signal line **20** is a linear conductor provided within the dielectric body **12** and extends on the front surface of the dielectric sheet **18c** in the x-axis direction. Both the respective end portions of the signal line **20** overlap with the external terminals **16a** and **16b** and the connection conductors **17a** and **17b** in a planar view from the z-axis direction. The signal line **20** is manufactured using a metal material whose specific resistance is small and whose main component is silver or copper.

As illustrated in FIG. 9, the ground conductor **22** (a second ground conductor) is provided within the dielectric body **12** on the positive direction side in the z-axis direction, compared with the signal line **20** (in other words, on the front surface side of the dielectric body **12**), and in more detail, provided on the front surface of the dielectric sheet **18a**. The ground conductor **22** extends in the x-axis direction along the signal line **20** on the front surface of the dielectric sheet **18a**, and faces the signal line **20** across the dielectric sheets **18a** and **18b**, as illustrated in FIG. 9.

In addition, the ground conductor **22** includes a main conductor **22a** and terminal conductors **22b** and **22c**. The main conductor **22a** is provided on the front surface of the line portion **18a-a**, and extends in the x-axis direction. In the main conductor **22a**, practically no opening is provided. In other words, the main conductor **22a** is an electrode continuously extending along the signal line **20** in the line portion **12a** in the x-axis direction, namely, a so-called flat plate-shaped electrode. In this regard, however, it is not necessary for the main conductor **22a** to completely cover the line portion **12a**, and for example, a small hole or the like may also be provided in a predetermined position in the main conductor **22a** so as to allow gas to escape, the gas occurring when the thermoplastic resin of the dielectric sheet **18** is subjected to thermocompression bonding. The main conductor **22a** is manufactured using a metal material whose specific resistance is small and whose main component is silver or copper.

The terminal conductor **22b** is provided on the front surface of the connection portion **18a-b**, and defines a rectangular or substantially rectangular ring surrounding the circumference of the external terminal **16a**. The terminal conductor **22b** is connected to an end portion of the main conductor **22a** on the negative direction side in the x-axis direction. The terminal conductor **22c** is provided on the front surface of the connection portion **18a-c**, and has a ring-shaped rectangular or substantially rectangular shape surrounding the circumference of the external terminal **16b**. The terminal conductor **22c** is connected to an end portion of the main conductor **22a** on the positive direction side in the x-axis direction.

Here, the characteristic impedance of the high-frequency signal transmission line **10a** is defined mainly on the basis of a facing area and a distance between the signal line **20** and the ground conductor **22** and the relative permittivities of the dielectric sheets **18a** to **18d**. Therefore, in a case where the characteristic impedance of the high-frequency signal transmission line **10a** is set to 50 $\Omega$ , for example, designing is performed, for example, so that the characteristic impedance of the high-frequency signal transmission line **10a** becomes 55 $\Omega$ , for example, because of the signal line **20** and the ground conductor **22**, the 55 $\Omega$  being slightly higher than 50 $\Omega$ . In addition, the shape of the after-mentioned ground conductor **24** is adjusted so that the characteristic impedance of the high-frequency signal transmission line **10a** becomes 50 $\Omega$ .

13

because of the signal line 20, the ground conductor 22, and the after-mentioned ground conductor 24. As described above, the ground conductor 22 functions as a reference-ground electrode.

As illustrated in FIG. 9, the ground conductor 24 (a first ground conductor) is provided within the dielectric body 12 on the negative direction side in the z-axis direction, compared with the signal line 20 (in other words, on the back surface side of the dielectric body 12), and in more detail, provided on the front surface of the dielectric sheet 18d. The ground conductor 24 extends in the x-axis direction along the signal line 20 on the front surface of the dielectric sheet 18d, and faces the signal line 20 across the dielectric sheet 18c, as illustrated in FIG. 9. The ground conductor 24 is manufactured using a metal material whose specific resistance is small and whose main component is silver or copper.

In addition, the ground conductor 24 includes a line conductor 24a and terminal conductors 24b and 24c. The line conductor 24a is provided on the front surface of the line portion 18d-a, and extends in the x-axis direction. In addition, a plurality of openings 30 in which no conductor layers are formed and a plurality of bridge portions 60 serving as portions in which conductor layers are formed are alternately provided along the signal line 20, and hence, the line conductor 24a has a ladder shape. As illustrated in FIG. 9, in a planar view from the z-axis direction, the opening 30 has an elliptical or substantially elliptical shape having a longitudinal direction in the x-axis direction, and overlaps with the signal line 20. As a result, in a planar view from the z-axis direction, the signal line 20 alternately overlaps with the openings 30 and the bridge portions 60. In addition, the openings 30 are arranged at equal intervals.

The terminal conductor 24b is provided on the front surface of the connection portion 18d-b, and defines a rectangular or substantially rectangular ring surrounding the center of the connection portion 18d-b. As a result, in the ground conductor 24, a conductor-missing portion Oa is provided in a region surrounded by the terminal conductor 24b. In addition, an end portion of the signal line 20 on the negative direction side in the x-axis direction is located within the conductor-missing portion Oa in a planar view from the z-axis direction. The terminal conductor 24b is connected to an end portion of the line conductor 24a on the negative direction side in the x-axis direction.

The terminal conductor 24c is provided on the front surface of the connection portion 18d-c, and defines a rectangular or substantially rectangular ring surrounding the center of the connection portion 18d-c. As a result, in the ground conductor 24, a conductor-missing portion Ob is provided in a region surrounded by the terminal conductor 24c. In addition, an end portion of the signal line 20 on the positive direction side in the x-axis direction is located within the conductor-missing portion Ob in a planar view from the z-axis direction. The terminal conductor 24c is connected to an end portion of the line conductor 24a on the positive direction side in the x-axis direction.

The ground conductor 24 is an auxiliary ground conductor also functioning as a shield. In addition, as described above, the ground conductor 24 is designed in order to make a final adjustment so that the characteristic impedance of the high-frequency signal transmission line 10a becomes about 50Ω, for example. Specifically, the size of the opening 30, the line width of the bridge portion 60, and so forth are designed.

As described above, no opening is provided in the ground conductor 22, and the openings 30 are provided in the ground conductor 24. Accordingly, an area where the ground conduc-

14

tor 24 and the signal line 20 face each other is smaller than an area where the ground conductor 22 and the signal line 20 face each other.

Here, as illustrated in FIG. 9, in the high-frequency signal transmission line 10a, a region where the opening 30 is provided is referred to as a region A1, and a region where the bridge portion 60 is provided is referred to as a region A2. In other words, the signal line 20 overlaps with the opening 30 in the region A1, and the signal line 20 overlaps with the bridge portion 60 and does not overlap with the opening 30, in the region A2. The regions A1 and the regions A2 are alternately arranged in the x-axis direction.

In addition, as illustrated in FIG. 9, the line width Wa of the signal line 20 in the region A1 is larger than the line width Wb of the signal line 20 in the region A2. Since the signal line 20 does not overlap with the ground conductor 24 in the region A1, it is possible to reduce the high-frequency resistance value of the signal line by enlarging the line width Wa. On the other hand, since the signal line 20 overlaps with the ground conductor 24 in the region A2, the line width Wb is set to be smaller than the region A1 so as to suppress the reduction of the high-frequency resistance value.

The via hole conductor b11 penetrates the connection portion 18a-b of the dielectric sheet 18a in the z-axis direction, and connects the external terminal 16a and the connection conductor 17a to each other. The via hole conductor b13 penetrates the connection portion 18b-b of the dielectric sheet 18b in the z-axis direction, and connects the connection conductor 17a and an end portion of the signal line 20 on the negative direction side in the x-axis direction to each other. As a result, an end portion of the signal line 20 on the negative direction side in the x-axis direction is connected to the external terminal 16a.

The via hole conductor b12 penetrates the connection portion 18a-c of the dielectric sheet 18a in the z-axis direction, and connects the external terminal 16b and the connection conductor 17b to each other. The via hole conductor b14 penetrates the connection portion 18b-c of the dielectric sheet 18b in the z-axis direction, and connects the connection conductor 17b and an end portion of the signal line 20 on the positive direction side in the x-axis direction to each other. As a result, an end portion of the signal line 20 on the positive direction side in the x-axis direction is connected to the external terminal 16b. The via hole conductors b11 to b14 are manufactured using metal materials whose specific resistances are small and whose main components are silver or copper.

The plural via hole conductors B1 to B3 penetrate the line portions 18a-a, 18b-a, and 18c-a of the dielectric sheets 18a, 18b, and 18c in the z-axis direction and are laid out in lines in the line portions 18a-a, 18b-a, and 18c-a at equal intervals, respectively. In a planar view from the z-axis direction, the via hole conductors B1 to B3 are provided on a positive direction side in the y-axis direction, compared with the signal line 20. In addition, the via hole conductors B1 to B3 configure one via hole conductor by being connected to each other, and connect the ground conductor 22 and the ground conductor 24 to each other. The via hole conductors B1 to B3 are manufactured using metal materials whose specific resistances are small and whose main components are silver or copper.

The plural via hole conductors B4 to B6 penetrate the line portions 18a-a, 18b-a, and 18c-a of the dielectric sheets 18a, 18b, and 18c in the z-axis direction and are laid out in lines in the line portions 18a-a, 18b-a, and 18c-a at equal intervals, respectively. In a planar view from the z-axis direction, the via hole conductors B4 to B6 are provided on a negative direction

## 15

side in the y-axis direction, compared with the signal line 20. In addition, the via hole conductors B4 to B6 configure one via hole conductor by being connected to each other, and connect the ground conductor 22 and the ground conductor 24 to each other. The via hole conductor B4 to B6 are manufactured using metal materials whose specific resistances are small and whose main components are silver or copper.

As described above, the signal line 20 and the ground conductors 22 and 24 define a triplate-type strip line structure. In addition, as illustrated in FIG. 10, an interval between the signal line 20 and the ground conductor 22 is approximately equal to the thickness T1 of the sum of the dielectric sheets 18a and 18b, and preferably ranges, for example, from about 50 μm to about 300 μm. In the present preferred embodiment, the interval between the signal line 20 and the ground conductor 22 preferably is about 150 μm, for example. On the other hand, as illustrated in FIG. 10, an interval between the signal line 20 and the ground conductor 24 is approximately equal to the thickness T2 of the dielectric sheet 18c, and ranges, for example, from about 10 μm to about 100 μm. In the present preferred embodiment, the interval between the signal line 20 and the ground conductor 24 preferably is about 50 μm, for example. In other words, the thickness T1 is designed so as to be larger than the thickness T2.

The protective layer 14 covers substantially the entire surface of the front surface of the dielectric sheet 18a. As a result, the protective layer 14 covers the ground conductor 22. The protective layer 14 is made of, for example, a flexible resin such as a resist material.

In addition, as illustrated in FIG. 9, the protective layer 14 includes a line portion 14a and connection portions 14b and 14c. The line portion 14a covers the main conductor 22a by covering the entire surface of the front surface of the line portion 18a-a.

The connection portion 14b is connected to an end portion of the line portion 14a on the negative direction side in the x-axis direction, and covers the front surface of the connection portion 18a-b. In this regard, however, in the connection portion 14b, openings Ha to Hd are provided. The opening Ha is a rectangular or substantially rectangular opening provided at substantially the center of the connection portion 14b. The external terminal 16a is exposed to the outside through the opening Ha. In addition, the opening Hb is a rectangular or substantially rectangular opening provided on the positive direction side of the opening Ha in the y-axis direction. The opening Hc is a rectangular or substantially rectangular opening provided on the negative direction side of the opening Ha in the x-axis direction. The opening Hd is a rectangular or substantially rectangular opening provided on the negative direction side of the opening Ha in the y-axis direction. The terminal conductor 22b is exposed to the outside through the openings Hb to Hd, and hence, functions as an external terminal.

The connection portion 14c is connected to an end portion of the line portion 14a on the positive direction side in the x-axis direction, and covers the front surface of the connection portion 18a-c. In this regard, however, in the connection portion 14c, openings He to Hh are provided. The opening He is a rectangular or substantially rectangular opening provided at substantially the center of the connection portion 14c. The external terminal 16b is exposed to the outside through the opening He. In addition, the opening Hf is a rectangular or substantially rectangular opening provided on the positive direction side of the opening He in the y-axis direction. The opening Hg is a rectangular or substantially rectangular opening provided on the positive direction side of the opening He in the x-axis direction. The opening Hh is a rectangular or

## 16

substantially rectangular opening provided on the negative direction side of the opening He in the y-axis direction. The terminal conductor 22c is exposed to the outside through the openings Hf to Hh, and hence, functions as an external terminal.

The adjustment plate 15a is provided on the back surface of the connection portion 12b of the dielectric body 12, and a rectangular or substantially rectangular metal plate overlapping with at least a portion of the conductor-missing portion Oa in a planar view from the z-axis direction. Furthermore, the adjustment plate 15a is not electrically connected to any one of the signal line 20 and the ground conductors 22 and 24. In more detail, the adjustment plate 15a overlaps with the whole of the conductor-missing portion Oa in a planar view from the z-axis direction, and hence, overlaps with an end portion of the signal line 20 on the negative direction side in the x-axis direction. As a result, capacitance is generated between the adjustment plate 15a and an end portion of the signal line 20 on the negative direction side in the x-axis direction. Furthermore, the adjustment plate 15a protrudes out of the conductor-missing portion Oa, and hence, overlaps with the terminal conductor 24b of the ground conductor 24. As a result, capacitance is generated between the adjustment plate 15a and the terminal conductor 24b of the ground conductor 24.

The adjustment plate 15b is provided on the back surface of the connection portion 12c of the dielectric body 12, and a rectangular or substantially rectangular metal plate overlapping with at least a portion of the conductor-missing portion Ob in a planar view from the z-axis direction. Furthermore, the adjustment plate 15b is not electrically connected to any one of the signal line 20 and the ground conductors 22 and 24. In more detail, the adjustment plate 15b overlaps with the whole of the conductor-missing portion Ob in a planar view from the z-axis direction, and hence, overlaps with an end portion of the signal line 20 on the positive direction side in the x-axis direction. As a result, capacitance is generated between the adjustment plate 15b and an end portion of the signal line 20 on the positive direction side in the x-axis direction. Furthermore, the adjustment plate 15b protrudes out of the conductor-missing portion Ob, and hence, overlaps with the terminal conductor 24c of the ground conductor 24. As a result, capacitance is generated between the adjustment plate 15b and the terminal conductor 24c of the ground conductor 24.

In addition, since the configurations of the connectors 100a and 100b in the high-frequency signal transmission line 10a are the same as the configurations of the connectors 100a and 100b in the high-frequency signal transmission line 10, the description thereof will be omitted.

According to the high-frequency signal transmission line 10a configured in such a way as described above, it is possible to significantly reduce or prevent the mismatching of characteristic impedances in the connectors 100a and 100b with respect to predetermined characteristic impedances, in the same way as the high-frequency signal transmission line 10. FIG. 11 is a graph illustrating the characteristic impedance of the high-frequency signal transmission line 10a according to the second preferred embodiment. A vertical axis indicates the characteristic impedance, and a horizontal axis indicates an x-axis. A solid line in FIG. 11 indicates the characteristic impedance of the high-frequency signal transmission line 10a, and a dotted line in FIG. 11 indicates the characteristic impedance of a high-frequency signal transmission line according to a comparative example. In the high-frequency signal transmission line according to the comparative example, the adjustment plates 15a and 15b are not provided.

17

As illustrated in FIG. 11, in the high-frequency signal transmission line 10a, in the same way as the high-frequency signal transmission line 10, the connectors 100a and 100b have been designed so that the characteristic impedances of the connectors 100a and 100b become slightly higher than a predetermined characteristic impedance. In addition, the conductor-missing portions Oa and Ob and the adjustment plates 15a and 15b are provided, and hence, the characteristic impedances of the connectors 100a and 100b are slightly reduced. As a result, in the high-frequency signal transmission line 10a, it is possible to match the characteristic impedances of the connectors 100a and 100b to the predetermined characteristic impedance with a high degree of accuracy.

In addition, in the high-frequency signal transmission line 10a, the characteristic impedance of the signal line 20 in the region A1 is higher than the characteristic impedance of the signal line in the region A2. In more detail, as described below, the characteristic impedance of the signal line 20 fluctuates in such a manner that, between the two adjacent bridge portions 60, the characteristic impedance of the signal line 20 decreases from a maximum value Z1 to a minimum value Z2 after increasing from the minimum value Z2 to the maximum value Z1, with coming close from one bridge portion 60 to the other bridge portion 60.

The width of the opening 30 in the y-axis direction is maximized in the center of the region A1 in the x-axis direction, and decreases with coming close to both end portions of the region A1 in the x-axis direction. Therefore, a distance between the signal line 20 and the ground conductor 24 in the region A1 is maximized in the center of the region A1 in the x-axis direction, and decreases with coming close to both end portions of the region A1 in the x-axis direction. As a result, the intensity of a magnetic field occurring in the signal line 20 in the center of the region A1 in the x-axis direction becomes larger than the intensities of magnetic fields occurring in the signal line 20 in both end portions of the region A1 in the x-axis direction. In other words, an inductance component in the center of the region A1 in the x-axis direction becomes large. In other words, an L property becomes dominant in the center of the region A1 in the x-axis direction.

On the other hand, the bridge portion 60 is provided in the region A2. Therefore, a distance between the signal line 20 and the ground conductor 24 in the region A2 is smaller than the distance between the signal line 20 and the ground conductor 24 in the region A1. As a result, in addition to it that capacitance occurring in the signal line 20 in the region A2 becomes larger than capacitance occurring in the signal line 20 in the region A1, a magnetic field intensity in the region A2 becomes smaller than a magnetic field intensity in the region A1. In other words, a C property becomes dominant in the region A2.

As a result of the above, since capacitance rarely occurs between the signal line 20 and the ground conductor 24 in the center of the region A1 in the x-axis direction, the maximum value Z1 occurs due mainly to the inductance of the signal line 20. In addition, in the region A2, since large capacitance has occurred between the signal line 20 and the ground conductor 24, the minimum value Z2 occurs due mainly to the capacitance. As a result, as illustrated in FIG. 11, the characteristic impedance of the signal line 20 periodically fluctuates between the maximum value Z1 and the minimum value Z2. The maximum value Z1 preferably is, for example, about 70Ω. The minimum value Z2 preferably is, for example, about 30Ω. In this regard, however, the characteristic impedance of the signal line 20 in the region A1 and the characteristic impedance in the region A2 are designed so that the

18

characteristic impedance of the whole signal line 20 becomes a predetermined characteristic impedance (for example, about 50Ω).

In addition, according to the high-frequency signal transmission line 10a, it is possible to reduce a transmission loss associated with the stabilization of a ground potential in the ground conductor 24, and it is possible to improve a shielding characteristic. In more detail, in the high-frequency signal transmission line 10a, the width of the opening 30 in the center of the region A1 in the x-axis direction is wider than the widths of the opening 30 in both end portions of the region A1 in the x-axis direction. As a result, in the high-frequency signal transmission line 10a, the magnetic field energy of the signal line 20 located in the center of the region A1 in the x-axis direction becomes higher than the magnetic field energies of the signal line 20 located in both end portions of the region A1 in the x-axis direction. In addition, the magnetic field energy of the signal line 20 located in the region A2 becomes lower than the magnetic field energies of the signal line 20 located in both end portions of the region A1 in the x-axis direction. Accordingly, as illustrated in FIG. 11, the characteristic impedance of the signal line 20 turns out to repeatedly fluctuate in the order of Z2, Z1, Z2, . . . . Accordingly, in the signal line 20, the fluctuation of a magnetic field energy in portions adjacent to each other in the x-axis direction becomes moderate. As a result, a magnetic field energy becomes small in a boundary between the regions A1 and A2, the fluctuation of the ground potential of the ground conductor is significantly reduced or prevented, and the occurrence of unnecessary radiation and the transmission loss of a high-frequency signal is significantly reduced or prevented.

Furthermore, in the high-frequency signal transmission line 10a, in a case of being disposed in an electronic device such as the electronic device 200 illustrated in FIGS. 5A and 5B, the flat plate-shaped ground conductor 22 is disposed on a battery pack 206 side, compared with the signal line 20. Therefore, it is possible to significantly reduced or prevented electrical interference from the battery pack 206 side to the signal line 20. Accordingly, it is possible to obtain a high-frequency signal transmission line whose transmission loss is small even if a metal member such as the battery pack 206 is near.

### Third Preferred Embodiment

Hereinafter, the configuration of a high-frequency signal transmission line according to a third preferred embodiment of the present invention will be described with reference to drawings. FIG. 12 is an exploded view of the dielectric body 12 of a high-frequency signal transmission line 10b according to the third preferred embodiment. In addition, as for the appearance perspective view of the high-frequency signal transmission line 10b, FIGS. 1A and 1B are incorporated.

The high-frequency signal transmission line 10b is different from the high-frequency signal transmission line 10a mainly in that the ground conductor 24 is not provided. Hereinafter, the high-frequency signal transmission line 10b will be described in detail with a focus on such a difference.

As illustrated in FIGS. 1A and 1B and FIG. 12, the external terminal 16a is a rectangular or substantially rectangular conductor provided on the vicinity of the center of the front surface of the connection portion 18a-b. As illustrated in FIGS. 1A and 1B and FIG. 12, the external terminal 16b is a rectangular or substantially rectangular conductor provided on the vicinity of the center of the front surface of the connection portion 18a-c. The external terminals 16a and 16b are manufactured using metal materials whose specific resis-

19

tances are small and whose main components are silver or copper. In addition, the surfaces of the external terminals **16a** and **16b** preferably are gold-plated.

As illustrated in FIG. 12, the signal line **20** is a linear conductor provided within the dielectric body **12** and extends on the front surface of the dielectric sheet **18b** in the x-axis direction. The line width of the signal line **20** remains steady. Both the respective end portions of the signal line **20** overlap with the external terminals **16a** and **16b** in a planar view from the z-axis direction. The signal line **20** is manufactured using a metal material whose specific resistance is small and whose main component is silver or copper.

The via hole conductor **b11** penetrates the connection portion **18a-b** of the dielectric sheet **18a** in the z-axis direction, and connects the external terminal **16a** and an end portion of the signal line **20** on the negative direction side in the x-axis direction to each other. The via hole conductor **b12** penetrates the connection portion **18a-c** of the dielectric sheet **18a** in the z-axis direction, and connects the external terminal **16b** and an end portion of the signal line **20** on the positive direction side in the x-axis direction to each other. The via hole conductors **b11** and **b12** are manufactured using metal materials whose specific resistances are small and whose main components are silver or copper.

As illustrated in FIG. 12, the ground conductor **22** (a first ground conductor) is provided within the dielectric body **12** on the positive direction side in the z-axis direction, compared with the signal line **20** (in other words, on the front surface side of the dielectric body **12**), and in more detail, provided on the front surface of the dielectric sheet **18a**. The ground conductor **22** extends in the x-axis direction along the signal line **20** on the front surface of the dielectric sheet **18a**, and faces the signal line **20** across the dielectric sheets **18a** and **18b**, as illustrated in FIG. 12.

In addition, the ground conductor **22** includes a main conductor **22a** and terminal conductors **22b** and **22c**. The main conductor **22a** is provided on the front surface of the line portion **18a-a**, and extends in the x-axis direction. In the main conductor **22a**, practically no opening is provided. In other words, the main conductor **22a** is an electrode continuously extending along the signal line **20** in the line portion **12a** in the x-axis direction, namely, a so-called flat plate-shaped electrode. In this regard, however, it is not necessary for the main conductor **22a** to completely cover the line portion **12a**, and for example, a small hole or the like may also be provided in a predetermined position in the main conductor **22a** so as to allow gas to escape, the gas occurring when the thermoplastic resin of the dielectric sheet **18** is subjected to thermocompression bonding. The main conductor **22a** is manufactured using a metal material whose specific resistance is small and whose main component is silver or copper.

The terminal conductor **22b** is provided on the front surface of the connection portion **18a-b**, and defines a rectangular or substantially rectangular ring surrounding the circumference of the external terminal **16a**. As a result, in the ground conductor **22**, a conductor-missing portion **Oa** is provided in a region surrounded by the terminal conductor **22b**. The external terminal **16a** and an end portion of the signal line **20** on the negative direction side in the x-axis direction are located within the conductor-missing portion **Oa** in a planar view from the z-axis direction. The terminal conductor **22b** is connected to an end portion of the main conductor **22a** on the negative direction side in the x-axis direction.

The terminal conductor **22c** is provided on the front surface of the connection portion **18a-c**, and has a ring-shaped rectangular or substantially rectangular shape surrounding the circumference of the external terminal **16b**. As a result, in the

20

ground conductor **22**, a conductor-missing portion **Ob** is provided in a region surrounded by the terminal conductor **22c**. The external terminal **16b** and an end portion of the signal line **20** on the positive direction side in the x-axis direction are located within the conductor-missing portion **Ob** in a planar view from the z-axis direction. The terminal conductor **22c** is connected to an end portion of the main conductor **22a** on the positive direction side in the x-axis direction.

Since a protective layer **14** and adjustment plates **15a** and **15b** in the high-frequency signal transmission line **10b** are the same as the protective layer **14** and the adjustment plates **15a** and **15b** in the high-frequency signal transmission line **10a**, the description thereof will be omitted.

As described above, in the high-frequency signal transmission lines **10** and **10a**, the conductor-missing portions **Oa** and **Ob** are provided in the ground conductors **24** and **25** provided on the negative direction side in the z-axis direction, compared with the signal line **20** (in other words, on the back surface side of the dielectric body **12**). On the other hand, as illustrated in FIG. 12, in the high-frequency signal transmission line **10b**, the ground conductor **24** or **25** does not exist in which the conductor-missing portions **Oa** and **Ob** are provided. Instead, in the high-frequency signal transmission line **10b**, the conductor-missing portions **Oa** and **Ob** are provided in the ground conductor **22** provided on the positive direction side in the z-axis direction, compared with the signal line **20** (in other words, on the front surface side of the dielectric body **12**). In other words, the ground conductor **22**, **24**, or **25** in which the conductor-missing portions **Oa** and **Ob** are provided may also be provided on the positive direction side in the z-axis direction, compared with the signal line **20**, and may also be provided on the negative direction side in the z-axis direction, compared with the signal line **20**.

According to the high-frequency signal transmission line **10b** configured in such a way as described above, it is possible to significantly reduce or prevent mismatching of characteristic impedances in the connectors **100a** and **100b** with respect to predetermined characteristic impedances, in the same way as the high-frequency signal transmission line **10a**. In more detail, in the high-frequency signal transmission line **10b**, the adjustment plates **15a** and **15b** are individually provided on the back surface of the dielectric body **12**, and overlap with at least portions of the conductor-missing portions **Oa** and **Ob**, respectively, in a planar view from the z-axis direction. As a result, capacitances **C2** turn out to be generated between the adjustment plates **15a** and **15b** and the end portions of the signal line **20**. Furthermore, capacitances **C3** turn out to be generated between the adjustment plates **15a** and **15b** and the terminal conductors **22b** and **22c** of the ground conductor **22**. In other words, between the signal line **20** and the ground conductor **22**, the capacitances **C2** and **C3** are connected in series, as illustrated in FIG. 7.

Here, when the capacitances **C2** and **C3** have been connected in series, the combined capacitance **Ct** of the capacitances **C2** and **C3** becomes a minute value. Accordingly, the minute combined capacitances **Ct** are generated in the connectors **100a** and **100b**, and it is possible to slightly reduce the characteristic impedances of the connectors **100a** and **100b**. In other words, it is possible to finely adjust the characteristic impedances of the connectors **100a** and **100b**. As a result, in the high-frequency signal transmission line **10b**, by providing the conductor-missing portions **Oa** and **Ob** and the adjustment plates **15a** and **15b**, it is possible to match the characteristic impedances of the connectors **100a** and **100b** to the predetermined characteristic impedances with a high degree of accuracy.

## 21

In addition, in the high-frequency signal transmission line 10b, in the same way as the high-frequency signal transmission line 10a, the large deformations of the connection portions 12b and 12c are significantly reduced or prevented, and the damages of the connection portions 12b and 12c are significantly reduced or prevented.

Furthermore, in the high-frequency signal transmission line 10b, in a case of being disposed in an electronic device such as the electronic device 200 illustrated in FIGS. 5A and 5B, the flat plate-shaped ground conductor 22 is disposed on the battery pack 206 side, compared with the signal line 20. Therefore, it is possible to significantly reduce or prevent electrical interference from the battery pack 206 side to the signal line 20. Accordingly, it is possible to obtain a high-frequency signal transmission line whose transmission loss is small even if a metal member such as the battery pack 206 is near.

## First Example of Modification

Hereinafter, a high-frequency signal transmission line according to a first example of a modification of a preferred embodiment of the present invention will be described with reference to drawings. FIGS. 13A and 13B are appearance perspective views of a high-frequency signal transmission line 10c according to the first example of a modification.

The internal configuration of the high-frequency signal transmission line 10c preferably is the same as the internal configuration of any one of the high-frequency signal transmission lines 10 and 10a. The high-frequency signal transmission line 10c is different from the high-frequency signal transmission lines 10 and 10a in a method for sticking the adjustment plates 15a and 15b. In more detail, in the high-frequency signal transmission lines 10 and 10a, the adjustment plates 15a and 15b are stuck to the dielectric body 12 preferably using an adhesive. In general, the adhesive preferably is a relatively thin layer.

On the other hand, in the high-frequency signal transmission line 10c, the adjustment plates 15a and 15b are stuck to the dielectric body 12 using relatively thick adhesive sheets 40a and 40b (adhesives). Accordingly, by adjusting the thicknesses of the adhesive sheets 40a and 40b, it is possible to adjust the magnitudes of capacitances between the adjustment plates 15a and 15b and the signal line 20 and the magnitudes of capacitances between the adjustment plates 15a and 15b and the ground conductors 24 and 25. Accordingly, it is only necessary to design the thicknesses of the adhesive sheets 40a and 40b so that the characteristic impedances of the connectors 100a and 100b become a predetermined characteristic impedance (e.g., about 50Ω).

## Second Example of Modification

Hereinafter, a high-frequency signal transmission line according to a second example of a modification of a preferred embodiment of the present invention will be described with reference to drawings. FIGS. 14A and 14B are appearance perspective views of a high-frequency signal transmission line 10d according to the second example of a modification.

The internal configuration of the high-frequency signal transmission line 10d preferably is the same as the internal configuration of any one of the high-frequency signal transmission lines 10 and 10a. The high-frequency signal transmission line 10d is different from the high-frequency signal transmission lines 10 and 10a in the shapes of the adjustment plates 15a and 15b. In more detail, in the high-frequency

## 22

signal transmission lines 10 and 10a, the adjustment plates 15a and 15b preferably have rectangular or substantially rectangular shapes.

On the other hand, in the high-frequency signal transmission line 10d, holes H1 and H2 and cutouts E1 and E2 are provided in the adjustment plates 15a and 15b. In this way, by providing the holes H1 and H2 and the cutouts E1 and E2, it is possible to adjust the magnitudes of capacitances between the adjustment plates 15a and 15b and the signal line 20 and the magnitudes of capacitances between the adjustment plates 15a and 15b and the ground conductors 24 and 25. Accordingly, it is only necessary to design the shapes of the adjustment plates 15a and 15b so that the characteristic impedances of the connectors 100a and 100b become a predetermined characteristic impedance (e.g., about 50Ω).

## Fourth Preferred Embodiment

Hereinafter, the configuration of a high-frequency signal transmission line 10e according to a fourth preferred embodiment of the present invention will be described with reference to drawings. FIG. 15 and FIG. 16 are appearance perspective views of the high-frequency signal transmission line 10e according to the fourth preferred embodiment. FIG. 17 is an exploded perspective view of the dielectric body 12 of the high-frequency signal transmission line 10e in FIG. 15. In what follows, the lamination direction of the high-frequency signal transmission line 10e is defined as a z-axis direction. In addition, the longitudinal direction of the high-frequency signal transmission line 10e is defined as an x-axis direction, and a direction perpendicular to the x-axis direction and the z-axis direction is defined as a y-axis direction.

The high-frequency signal transmission line 10e is not connected to a circuit substrate through the connectors 100a and 100b but connected to a circuit substrate through terminal conductors 22b, 22c, 43a, and 43b.

The high-frequency signal transmission line 10e is a flat-cable flexible circuit substrate preferably used to connect two high-frequency circuits within, for example, an electronic device such as a cellular phone. As illustrated in FIG. 15 to FIG. 17, the high-frequency signal transmission line 10e includes the dielectric body 12, adjustment plates 15a and 15b, a signal line 20, ground conductors 22 and 24, terminal conductors 43a and 43b, and via hole conductors b11, b12, and B11 to B18.

As illustrated in FIG. 15 and FIG. 16, in a planar view from the z-axis direction, the dielectric body 12 is a plate-shaped member having flexibility and extending in the x-axis direction, and includes a line portion 12a and connection portions 12b and 12c. As illustrated in FIG. 17, the dielectric body 12 is a laminated body including a protective layer 14 and dielectric sheets 18a to 18c that are laminated in this order from the positive direction side in the z-axis direction to the negative direction side therein. In what follows, the main surface of the dielectric body 12 on a positive direction side in the z-axis direction is referred to as a front surface, and the main surface of the dielectric body 12 on a negative direction side in the z-axis direction is referred to as a back surface.

As illustrated in FIG. 15 and FIG. 16, the line portion 12a extends in the x-axis direction. The connection portions 12b and 12c are connected to an end portion of the line portion 12a on a negative direction side in the x-axis direction and an end portion of the line portion 12a on a positive direction side in the x-axis direction, respectively, and have respective rectangular shapes. The widths of the connection portions 12b and 12c in the y-axis direction are larger than the width of the line portion 12a in the y-axis direction.



## 23

As illustrated in FIG. 17, the dielectric sheets **18a** to **18c** extend in the x-axis direction, and preferably have the same or substantially the same shape as the dielectric body **12** in a planar view from the z-axis direction. The dielectric sheets **18a** to **18c** are preferably made of a thermoplastic resin having flexibility, such as polyimide or liquid crystalline polymer. Hereinafter, the main surfaces of the dielectric sheets **18a** to **18c** on the positive direction side in the z-axis direction are referred to as front surfaces, and the main surfaces of the dielectric sheets **18a** to **18c** on the negative direction side in the z-axis direction are referred to as back surfaces.

As illustrated in FIG. 17, the thickness **T1** of the dielectric sheet **18a** is larger than the thickness **T2** of the dielectric sheet **18b**. After the lamination of the dielectric sheets **18a** to **18c**, the thickness **T1** preferably ranges, for example, from about 50  $\mu\text{m}$  to about 300  $\mu\text{m}$ . In the present preferred embodiment, the thickness **T1** preferably is about 150  $\mu\text{m}$ , for example. In addition, the thickness **T2** preferably ranges, for example, from about 10  $\mu\text{m}$  to about 100  $\mu\text{m}$ , for example. In the present preferred embodiment, the thickness **T2** preferably is about 50  $\mu\text{m}$ , for example.

In addition, as illustrated in FIG. 17, the dielectric sheet **18a** includes a line portion **18a-a** and connection portions **18a-b** and **18a-c**. As illustrated in FIG. 17, the dielectric sheet **18b** includes a line portion **18b-a** and connection portions **18b-b** and **18b-c**. The dielectric sheet **18c** includes a line portion **18c-a** and connection portions **18c-b** and **18c-c**. The line portions **18a-a**, **18b-a**, and **18c-a** configure the line portion **12a**. The connection portions **18a-b**, **18b-b**, and **18c-b** define the connection portion **12b**. The connection portions **18a-c**, **18b-c**, and **18c-c** define the connection portion **12c**.

As illustrated in FIG. 17, the signal line **20** is a linear conductor through which a high-frequency signal is transmitted and which is provided within the dielectric body **12**. In the present preferred embodiment, the signal line **20** is a linear conductor that is provided on the front surface of the dielectric sheet **18b** and extends in the x-axis direction.

As illustrated in FIG. 17, an end portion of the signal line **20** on the negative direction side in the x-axis direction is located on a negative direction side in the y-axis direction, compared with the center of the connection portion **18b-b**. As illustrated in FIG. 17, an end portion of the signal line **20** on the positive direction side in the x-axis direction is located on the negative direction side in the y-axis direction, compared with the center of the connection portion **18b-c**. The signal line **20** is manufactured using a metal material whose specific resistance is small and whose main component is silver or copper. Here, that the signal line **20** is provided on the front surface of the dielectric sheet **18b** indicates that metal foil formed on the front surface of the dielectric sheet **18b** by plating is subjected to patterning and thus the signal line **20** is formed or that metal foil stuck to the front surface of the dielectric sheet **18b** is subjected to patterning and thus the signal line **20** is formed. In addition, since smoothing is performed on the surface of the signal line **20**, the surface roughness of a surface in contact with the dielectric sheet **18b** in the signal line **20** becomes larger than the surface roughness of a surface not in contact with the dielectric sheet **18b** in the signal line **20**.

As illustrated in FIG. 17, the ground conductor **22** is a flat plate-shaped conductor layer provided on the positive direction side in the z-axis direction, compared with the signal line **20**. In more detail, the ground conductor **22** is provided on the front surface of the dielectric sheet **18a**, and faces the signal line **20** across the dielectric sheet **18a**. In the ground conductor **22**, no opening is provided in a position in which to overlap with the signal line **20**. The ground conductor **22** is manufac-

## 24

tured using a metal material whose specific resistance is small and whose main component is silver or copper.

Here, that the ground conductor **22** is provided on the front surface of the dielectric sheet **18a** indicates that metal foil formed on the front surface of the dielectric sheet **18a** by plating is subjected to patterning and thus the ground conductor **22** is formed or that metal foil stuck to the front surface of the dielectric sheet **18a** is subjected to patterning and thus the ground conductor **22** is formed. In addition, since smoothing is performed on the surface of the ground conductor **22**, the surface roughness of a surface in contact with the dielectric sheet **18a** in the ground conductor **22** becomes larger than the surface roughness of a surface not in contact with the dielectric sheet **18a** in the ground conductor **22**.

In addition, as illustrated in FIG. 17, the ground conductor **22** includes a main conductor **22a** and terminal conductors **22b** and **22c**. The main conductor **22a** is provided on the front surface of the line portion **18a-a**, and extends in the x-axis direction. The terminal conductor **22b** is a rectangular or substantially rectangular conductor provided on the front surface of the connection portion **18a-b**. In more detail, the terminal conductor **22b** extends in the x-axis direction on a positive direction side in the y-axis direction, compared with the center of the connection portion **18a-b**, and functions as an external electrode. The terminal conductor **22b** is connected to an end portion of the main conductor **22a** on the negative direction side in the x-axis direction.

The terminal conductor **22c** is a rectangular or substantially rectangular conductor provided on the front surface of the connection portion **18a-c**. In more detail, the terminal conductor **22c** extends in the x-axis direction on the positive direction side in the y-axis direction, compared with the center of the connection portion **18a-c**, and functions as an external electrode. The terminal conductor **22c** is connected to an end portion of the main conductor **22a** on the positive direction side in the x-axis direction.

Here, the characteristic impedance of the high-frequency signal transmission line **10e** is defined mainly on the basis of a facing area and a distance between the signal line **20** and the ground conductor **22** and the relative permittivities of the dielectric sheets **18a** to **18c**. Therefore, in a case where the characteristic impedance of the high-frequency signal transmission line **10e** is set to 50 $\Omega$ , designing is performed, for example, so that the characteristic impedance of the high-frequency signal transmission line **10e** becomes 55 $\Omega$ , for example, because of the signal line **20** and the ground conductor **22**, the 55 $\Omega$  being slightly higher than 50 $\Omega$ . In addition, the shape of the ground conductor **24** is adjusted so that the characteristic impedance of the high-frequency signal transmission line **10e** becomes 50 $\Omega$  because of the signal line **20**, the ground conductor **22**, and the ground conductor **24**. As described above, the ground conductor **22** functions as a reference-ground electrode.

As illustrated in FIG. 17, the ground conductor **24** is a conductor layer provided on the negative direction side in the z-axis direction, compared with the signal line **20**. In more detail, the ground conductor **24** is provided on the front surface of the dielectric sheet **18c**, and faces the signal line **20** across the dielectric sheet **18b**. The ground conductor **24** is manufactured using a metal material whose specific resistance is small and whose main component is silver or copper.

Here, that the ground conductor **24** is provided on the front surface of the dielectric sheet **18c** indicates that metal foil formed on the front surface of the dielectric sheet **18c** by plating is subjected to patterning and thus the ground conductor **24** is formed or that metal foil stuck to the front surface of the dielectric sheet **18c** is subjected to patterning and thus the



25

ground conductor **24** is formed. In addition, since smoothing is performed on the surface of the ground conductor **24**, the surface roughness of a surface in contact with the dielectric sheet **18c** in the ground conductor **24** becomes larger than the surface roughness of a surface not in contact with the dielectric sheet **18c** in the ground conductor **24**.

In addition, as illustrated in FIG. 17, the ground conductor **24** includes a main conductor **24a** and terminal conductors **24b** and **24c**. The main conductor **24a** is provided on the front surface of the line portion **18c-a**, and extends in the x-axis direction. The terminal conductor **24b** is provided on the front surface of the connection portion **18c-b**, and preferably has a rectangular or substantially rectangular shape. The terminal conductor **24b** is connected to an end portion of the main conductor **24a** on the negative direction side in the x-axis direction. In this regard, however, in the terminal conductor **24b**, a rectangular or substantially rectangular conductor-missing portion **Oa** is provided. In a planar view from the z-axis direction, the conductor-missing portion **Oa** overlaps with an end portion of the signal line **20** on the negative direction side in the x-axis direction. The terminal conductor **24c** is provided on the front surface of the connection portion **18c-c**, and has a rectangular shape. The terminal conductor **24c** is connected to an end portion of the main conductor **24a** on the positive direction side in the x-axis direction. In this regard, however, in the terminal conductor **24c**, a rectangular or substantially rectangular conductor-missing portion **Ob** is provided. In a planar view from the z-axis direction, the conductor-missing portion **Ob** overlaps with an end portion of the signal line **20** on the positive direction side in the x-axis direction.

In addition, as illustrated in FIG. 17, in the main conductor **24a**, a plurality of openings **30** are provided that are arranged in the x-axis direction and have rectangular or substantially rectangular shapes. As a result, the main conductor **24a** has a ladder shape. In addition, in the ground conductor **24**, a portion sandwiched between the openings **30** adjacent to each other is referred to as a bridge portion **60**. The bridge portion **60** extends in the y-axis direction. In a planar view from the z-axis direction, the plural openings **30** and the plural bridge portions **60** alternately overlap with the signal line **20**. In addition, in the present preferred embodiment, the signal line **20** passes over, in the x-axis direction, the centers of the openings **30** and the bridge portions **60** in the y-axis direction.

The ground conductor **24** is an auxiliary ground conductor also functioning as a shield. In addition, as described above, the ground conductor **24** is designed in order to make a final adjustment so that the characteristic impedance of the high-frequency signal transmission line **10e** becomes 50Ω, for example. Specifically, the size of the opening **30**, the line width of the bridge portion **60**, and so forth are designed.

As described above, no opening is provided in the ground conductor **22**, and the opening **30** is provided in the ground conductor **24**. Accordingly, an area where the ground conductor **24** and the signal line **20** face each other is smaller than an area where the ground conductor **22** and the signal line **20** face each other.

The terminal conductor **43a** is a rectangular or substantially rectangular conductor provided on the front surface of the connection portion **18a-b**, and functions as an external electrode. In more detail, the terminal conductor **43a** extends in the x-axis direction, on the negative direction side in the y-axis direction, compared with the center of the connection portion **18a-b**. In addition, in a planar view from the z-axis direction, an end portion of the terminal conductor **43a** on the

26

positive direction side in the x-axis direction overlaps with an end portion of the signal line **20** on the negative direction side in the x-axis direction.

The terminal conductor **43b** is a rectangular or substantially rectangular conductor provided on the front surface of the connection portion **18a-c**, and functions as an external electrode. In more detail, the terminal conductor **43b** extends in the x-axis direction, on the negative direction side in the y-axis direction, compared with the center of the connection portion **18a-c**. In addition, in a planar view from the z-axis direction, an end portion of the terminal conductor **43b** on the negative direction side in the x-axis direction overlaps with an end portion of the signal line **20** on the positive direction side in the x-axis direction.

The signal line **20**, the ground conductors **22** and **24**, and the terminal conductors **43a** and **43b** have approximately the same thicknesses. The thicknesses of the signal line **20**, the ground conductors **22** and **24**, and the terminal conductors **43a** and **43b** preferably range, for example, from about 10 μm to about 20 μm.

As described above, the signal line **20** is sandwiched from both sides thereof in the z-axis direction, by the ground conductor **22** and the ground conductor **24**. In other words, the signal line **20**, the ground conductor **22**, and the ground conductor **24** define a triplate-type strip line structure. In addition, as illustrated in FIG. 17, an interval (a distance in the z-axis direction) between the signal line **20** and the ground conductor **22** is approximately equal to the thickness **T1** of the dielectric sheet **18a**, and preferably ranges, for example, from about 50 μm to about 300 μm. In the present preferred embodiment, the interval between the signal line **20** and the ground conductor **22** preferably is about 150 μm, for example. In addition, as illustrated in FIG. 17, an interval (a distance in the z-axis direction) between the signal line **20** and the ground conductor **24** is approximately equal to the thickness **T2** of the dielectric sheet **18b**, and preferably ranges, for example, from about 10 μm to about 100 μm. In the present preferred embodiment, the interval between the signal line **20** and the ground conductor **24** preferably is about 50 μm, for example. Accordingly, the distance between the signal line **20** and the ground conductor **24** in the z-axis direction is smaller than the distance between the signal line **20** and the ground conductor **22** in the z-axis direction.

As illustrated in FIG. 17, the plural via hole conductors **B11** penetrate the dielectric sheet **18a** in the z-axis direction, on the positive direction side in the y-axis direction compared with the signal line **20**, and are laid out in a line in the x-axis direction at equal intervals. As illustrated in FIG. 17, the plural via hole conductors **B12** penetrate the dielectric sheet **18b** in the z-axis direction, on the positive direction side in the y-axis direction compared with the signal line **20**, and are laid out in a line in the x-axis direction at equal intervals. The via hole conductors **B11** and **B12** configure one via hole conductor by being connected to each other. In addition, an end portion of the via hole conductor **B11** on the positive direction side in the z-axis direction is connected to the ground conductor **22**. An end portion of the via hole conductor **B12** on the negative direction side in the z-axis direction is connected to the ground conductor **24**, and, in more detail, connected to the ground conductor **24** on the positive direction side in the y-axis direction, compared with the bridge portion **60**. Via holes formed in the dielectric sheets **18a** and **18b** have been filled with a conductive paste whose main component is silver, tin, copper, or the like, the conductive paste has been solidified, and hence the via hole conductors **B11** and **B12** are formed.

27

As illustrated in FIG. 17, the plural via hole conductors B13 penetrate the dielectric sheet 18a in the z-axis direction, on the negative direction side in the y-axis direction compared with the signal line 20, and are laid out in a line in the x-axis direction at equal intervals. As illustrated in FIG. 17, the plural via hole conductors B14 penetrate the dielectric sheet 18b in the z-axis direction, on the negative direction side in the y-axis direction compared with the signal line 20, and are laid out in a line in the x-axis direction at equal intervals. The via hole conductors B13 and B14 configure one via hole conductor by being connected to each other. In addition, an end portion of the via hole conductor B13 on the positive direction side in the z-axis direction is connected to the ground conductor 22. An end portion of the via hole conductor B14 on the negative direction side in the z-axis direction is connected to the ground conductor 24, and, in more detail, connected to the ground conductor 24 on the negative direction side in the y-axis direction, compared with the bridge portion 60. Via holes formed in the dielectric sheets 18a and 18b have been filled with a conductive paste whose main component is silver, tin, copper, or the like, the conductive paste has been solidified, and hence the via hole conductors B13 and B14 are formed.

As illustrated in FIG. 17, the via hole conductor B15 penetrates the connection portion 18a-b of the dielectric sheet 18a in the z-axis direction. As illustrated in FIG. 17, the via hole conductor B16 penetrates the connection portion 18b-b of the dielectric sheet 18b in the z-axis direction. The via hole conductors B15 and B16 define one via hole conductor by being connected to each other. In addition, an end portion of the via hole conductor B15 on the positive direction side in the z-axis direction is connected to the terminal conductor 22b of the ground conductor 22. An end portion of the via hole conductor B16 on the negative direction side in the z-axis direction is connected to the terminal conductor 24b of the ground conductor 24. Via holes formed in the dielectric sheets 18a and 18b have been filled with a conductive paste whose main component is silver, tin, copper, or the like, the conductive paste has been solidified, and hence the via hole conductors B15 and B16 are formed.

As illustrated in FIG. 17, the via hole conductor B17 penetrates the connection portion 18a-c of the dielectric sheet 18a in the z-axis direction. As illustrated in FIG. 17, the via hole conductor B18 penetrates the connection portion 18b-c of the dielectric sheet 18b in the z-axis direction. The via hole conductors B17 and B18 define one via hole conductor by being connected to each other. In addition, an end portion of the via hole conductor B17 on the positive direction side in the z-axis direction is connected to the terminal conductor 22c of the ground conductor 22. An end portion of the via hole conductor B18 on the negative direction side in the z-axis direction is connected to the terminal conductor 24c of the ground conductor 24. Via holes formed in the dielectric sheets 18a and 18b have been filled with a conductive paste whose main component is silver, tin, copper, or the like, the conductive paste has been solidified, and hence the via hole conductors B17 and B18 are formed.

As illustrated in FIG. 17, the via hole conductor b11 penetrates the connection portion 18a-b of the dielectric sheet 18a in the z-axis direction, and connects the terminal conductor 43a and an end portion of the signal line 20 on the negative direction side in the x-axis direction to each other. As illustrated in FIG. 17, the via hole conductor b12 penetrates the connection portion 18a-c of the dielectric sheet 18a in the z-axis direction, and connects the terminal conductor 43b and an end portion of the signal line 20 on the positive direction side in the x-axis direction to each other. As a result, the signal

28

line 20 is connected between the terminal conductors 43a and 43b. Via holes formed in the dielectric sheets 18a and 18b have been filled with a conductive paste whose main component is silver, tin, copper, or the like, the conductive paste has been solidified, and hence the via hole conductors b11 and b12 are formed.

The protective layer 14 is insulation film provided on the front surface of the dielectric sheet 18a, and covers substantially the entire surface of the front surface of the dielectric sheet 18a. As a result, the protective layer 14 covers the ground conductor 22. The protective layer 14 is made of, for example, a flexible resin such as a resist material.

In addition, as illustrated in FIG. 17, the protective layer 14 includes a line portion 14a and connection portions 14b and 14c. The line portion 14a covers the main conductor 22a by covering the entire surface of the front surface of the line portion 18a-a.

The connection portion 14b is connected to an end portion of the line portion 14a on the negative direction side in the x-axis direction, and covers a portion of the front surface of the connection portion 18a-b. In this regard, however, as illustrated in FIG. 15, the connection portion 14b does not cover the terminal conductors 22b and 43a.

The connection portion 14c is connected to an end portion of the line portion 14a on the positive direction side in the x-axis direction, and covers a portion of the front surface of the connection portion 18a-c. In this regard, however, as illustrated in FIG. 15, the connection portion 14c does not cover the terminal conductors 22c and 43b.

The adjustment plate 15a is provided on the back surface of the connection portion 12b of the dielectric body 12 (in other words, the back surface of the connection portion 18c-b of the dielectric sheet 18c), and a rectangular or substantially rectangular metal plate overlapping with at least a portion of the conductor-missing portion Oa in a planar view from the z-axis direction. Furthermore, the adjustment plate 15a is not electrically connected to any one of the signal line 20 and the ground conductors 22 and 24, and is maintained at a floating potential. In more detail, the adjustment plate 15a overlaps with the whole of the conductor-missing portion Oa in a planar view from the z-axis direction, and hence, overlaps with an end portion of the signal line 20 on the negative direction side in the x-axis direction. As a result, capacitance is generated between the adjustment plate 15a and an end portion of the signal line 20 on the negative direction side in the x-axis direction. Furthermore, the adjustment plate 15a protrudes out of the conductor-missing portion Oa, and hence, overlaps with the terminal conductor 24b of the ground conductor 24 in a planar view from the z-axis direction. As a result, capacitance is generated between the adjustment plate 15a and the terminal conductor 24b of the ground conductor 24.

The adjustment plate 15b is provided on the back surface of the connection portion 12c of the dielectric body 12 (in other words, the back surface of the connection portion 18c-c of the dielectric sheet 18c), and a rectangular or substantially rectangular metal plate overlapping with at least a portion of the conductor-missing portion Ob in a planar view from the z-axis direction. Furthermore, the adjustment plate 15b is not electrically connected to any one of the signal line 20 and the ground conductors 22 and 24, and is maintained at a floating potential. In more detail, the adjustment plate 15b overlaps with the whole of the conductor-missing portion Ob in a planar view from the z-axis direction, and hence, overlaps with an end portion of the signal line 20 on the positive direction side in the x-axis direction. As a result, capacitance is generated between the adjustment plate 15b and an end

29

portion of the signal line **20** on the positive direction side in the x-axis direction. Furthermore, the adjustment plate **15b** protrudes out of the conductor-missing portion **Ob**, and hence, overlaps with the terminal conductor **24c** of the ground conductor **24** in a planar view from the z-axis direction. As a result, capacitance is generated between the adjustment plate **15b** and the terminal conductor **24c** of the ground conductor **24**. The adjustment plates **15a** and **15b** are defined by, for example, copper plates or SUS plates.

Next, a connection structure between the high-frequency signal transmission line **10e** and a circuit substrate will be described with reference to drawings. FIG. **18** is a perspective view of a connection portion between the high-frequency signal transmission line **10e** and a circuit substrate **202b**. FIG. **19** is a cross-sectional structural view of the connection portion between the high-frequency signal transmission line **10e** and the circuit substrate **202b**. In addition, a connection structure between the high-frequency signal transmission line **10e** and a circuit substrate **202a** and a connection structure between the high-frequency signal transmission line **10e** and the circuit substrate **202b** are equal to each other. Therefore, hereinafter, the connection structure between the high-frequency signal transmission line **10e** and the circuit substrate **202b** will be described.

As illustrated in FIG. **18**, the circuit substrate **202b** includes a substrate body **207**, external terminals **208b** and **208c**, and a resist **209**. The substrate body **207** embeds therein a feed circuit and so forth. The external terminals **208b** and **208c** are provided on the main surface of the substrate body **207** on the negative direction side in the z-axis direction, and arranged in this order from the positive direction side to the negative direction side in the y-axis direction. The external terminals **208b** and **208c** have rectangular or substantially rectangular shapes, and are manufactured using, for example, copper or the like. In a planar view from the z-axis, the direction resist **209** surrounds the circumferences of the external terminals **208b** and **208c**. As a result, the resist **209** also serves a function for the positioning of the high-frequency signal transmission line **10e**. As illustrated in FIG. **19**, the external terminals **208b** and **208c** are connected to the terminal conductors **22c** and **43b**, respectively, by a solder.

According to the high-frequency signal transmission line **10e** configured in such a way as described above, it is possible to significantly reduce or prevent mismatching of the characteristic impedances of both end portions of the signal line **20** with respect to predetermined characteristic impedances. FIG. **20** is a cross-sectional structural view of the high-frequency signal transmission line **10e** taken along a line XX-XX in FIG. **17**.

In the high-frequency signal transmission line **10e**, the adjustment plates **15a** and **15b** are individually provided on the back surface of the dielectric body **12**, and overlap with at least portions of the conductor-missing portions **Oa** and **Ob**, respectively, in a planar view from the z-axis direction. As a result, as illustrated in FIG. **20**, capacitances **C2** turn out to be generated between the adjustment plates **15a** and **15b** and the end portions of the signal line **20**. Furthermore, capacitances **C3** turn out to be generated between the adjustment plates **15a** and **15b** and the terminal conductors **24b** and **24c** of the ground conductor **24**. In other words, between the signal line **20** and the ground conductor **24**, the capacitances **C2** are **C3** are connected in series, as illustrated in FIG. **20**.

Here, when the capacitances **C2** and **C3** have been connected in series, the combined capacitance **Ct** of the capacitances **C2** and **C3** becomes a minute value. Accordingly, the minute combined capacitances **Ct** are generated in the end portions of the signal line **20**, and it is possible to slightly

30

reduce the characteristic impedances of the end portions of the signal line **20**. In other words, it is possible to finely adjust the characteristic impedances of the end portions of the signal line **20**. As a result, in the high-frequency signal transmission line **10e**, by providing the conductor-missing portions **Oa** and **Ob** and the adjustment plates **15a** and **15b**, it is possible to match the characteristic impedances of the end portions of the signal line **20** to the predetermined characteristic impedances with a high degree of accuracy.

In addition, the terminal conductors **22c** and **43b** may also be connected to the external terminals **208b** and **208c** by welding, for example.

In addition, stainless-steel metal plates may also be provided above the terminal conductors **22b**, **22c**, **43a**, and **43b**. As a result, the deformations of the connection portions **12b** and **12c** are significantly reduced or prevented. In addition, since the material of the stainless-steel metal plate is different from the materials of the terminal conductors **22b**, **22c**, **43a**, and **43b**, the characteristic impedance of the metal plate is different from the characteristic impedances of the terminal conductors **22b**, **22c**, **43a**, and **43b**. Accordingly, the characteristic impedance of the metal plate is easily mismatched with respect to a predetermined characteristic impedance. Therefore, in a case where the metal plate is applied to the high-frequency signal transmission line **10e**, it is only necessary to adjust the characteristic impedance of the metal plate because of the adjustment plates **15a** and **15b**.

#### Another Preferred Embodiment

A high-frequency signal transmission line according to the present invention is not limited to the high-frequency signal transmission lines **10** and **10a** to **10e** according to the above-mentioned preferred embodiments, and may be modified within the scope thereof.

In addition, the adjustment plates **15a** and **15b** may also be stuck to the dielectric body **12**, using, for example, a resist material.

In addition, while it has been assumed that the adjustment plates **15a** and **15b** preferably are metal plates, the adjustment plates **15a** and **15b** may also be insulating substrates such as glass epoxy resins, in which, for example, conductor layers are provided. In this case, since it is possible to process the conductor layer by etching, it is possible to process the conductor layer with a high degree of accuracy. Accordingly, it is possible to match the characteristic impedances of the connectors **100a** and **100b** to predetermined characteristic impedances with a high degree of accuracy.

In addition, in the high-frequency signal transmission line **10a**, the opening **30** may not exist in the ground conductor **24**. In addition, the plural openings **30** may be provided not in the ground conductor **24** but in the ground conductor **22**. Furthermore, the plural openings **30** may be provided in each of the ground conductors **22** and **24**.

In addition, the configurations illustrated in the high-frequency signal transmission lines **10** and **10a** to **10e** may also be combined.

In addition, it is not necessary for the signal line **20** and the adjustment plates **15a** and **15b** to overlap with each other in a planar view. In this case, the capacitances **C2** also occur between the signal line **20** and the adjustment plates **15a** and **15b** through the conductor-missing portions **Oa** and **Ob**. In the same way, it is not necessary for the ground conductors **22**, **24**, and **25** and the adjustment plates **15a** and **15b** to overlap with each other in a planar view.

## 31

In addition, the connectors **100a** and **100b** may also be provided on the respective different main surfaces of the dielectric body **12**.

In addition, the high-frequency signal transmission lines **10** and **10a** to **10e** may also be used as high-frequency signal transmission lines in RF circuit substrates such as antenna front-end modules.

As described above, preferred embodiments of the present invention are useful for a high-frequency signal transmission line and an electronic device, and in particular, is superior in terms of significantly reducing or preventing mismatching of a characteristic impedance in a connector with respect to a predetermined characteristic impedance.

While preferred embodiments of the present invention have been described above, it is to be understood that variations and modifications will be apparent to those skilled in the art without departing from the scope and spirit of the present invention. The scope of the present invention, therefore, is to be determined solely by the following claims.

What is claimed is:

1. A high-frequency signal transmission line comprising:  
a body including a plurality of insulator layers laminated on each other;  
a linear signal line provided in or on the body;  
a first ground conductor facing the signal line across at least one of the plurality of insulator layers; and  
an adjustment conductor; wherein  
the body includes a connection portion in which the signal line and an external circuit are electrically connected in a first main surface of the body, and a line portion in which the signal line is provided, the line portion extending from the connection portion;  
in the first ground conductor, a conductor-missing portion is provided in at least a portion of a region overlapping with the signal line, in a planar view from a lamination direction in the connection portion; and  
the adjustment conductor is provided in a second main surface of the body, and overlaps with at least a portion of the conductor-missing portion in the planar view from the lamination direction; and  
the adjustment conductor is not provided in the line portion.
2. The high-frequency signal transmission line according to claim 1, wherein a portion of the adjustment conductor overlaps with the signal line in the planar view of the body from the lamination direction.
3. The high-frequency signal transmission line according to claim 1, wherein the adjustment conductor includes an insulating substrate in which a metal plate or a conductor layer is provided.
4. The high-frequency signal transmission line according to claim 1, wherein the adjustment conductor is fixed to the body via an adhesive or a resist material.
5. The high-frequency signal transmission line according to claim 1, wherein the adjustment conductor is not electrically connected to the signal line or the first ground conductor.
6. The high-frequency signal transmission line according to claim 1, wherein the first ground conductor is provided on the first main surface side of the body, compared with the signal line.
7. The high-frequency signal transmission line according to claim 1, further comprising:  
an external electrode provided on the first main surface of the connection portion of the body and electrically connected to the signal line; wherein

## 32

the signal line is electrically connected to the external circuit through the external electrode.

8. The high-frequency signal transmission line according to claim 1, wherein capacitance is generated between the adjustment conductor and the signal line and capacitance is generated between the adjustment conductor and the first ground conductor.

9. The high-frequency signal transmission line according to claim 1, further comprising:

a second ground conductor provided on the first main surface side of the body, compared with the signal line, and facing the signal line across at least one of the plurality of insulator layers; wherein

the first ground conductor is provided on the second main surface side of the body, compared with the signal line; and

a plurality of openings are provided in at least one of the first ground conductor and the second ground conductor, the plurality of openings being arranged along the signal line in the planar view from the lamination direction.

10. The high-frequency signal transmission line according to claim 9, wherein

a characteristic impedance of the signal line in a first region overlapping with the openings is higher than a characteristic impedance of the signal line in a second region not overlapping with the openings; and

the characteristic impedance of the signal line in the first region and the characteristic impedance of the signal line in the second region are set so that a characteristic impedance of an entirety of the signal line is a predetermined characteristic impedance.

11. The high-frequency signal transmission line according to claim 1, further comprising:

a connector is mounted on the first main surface of the connection portion of the body, and is electrically connected to the signal line; wherein

the signal line is electrically connected to the external circuit through the connector.

12. The high-frequency signal transmission line according to claim 11, wherein the adjustment conductor is configured such that a characteristic impedance of the connector has a predetermined characteristic impedance.

13. An electronic device comprising:

a high-frequency signal transmission line; and  
a housing containing the high-frequency signal transmission line; wherein

the high-frequency signal transmission line includes:

a body including a plurality of insulator layers laminated on each other;

a linear signal line provided in or on the body;

a first ground conductor facing the signal line across at least one of the plurality of insulator layers; and  
an adjustment conductor; wherein

the body includes a connection portion in which the signal line and an external circuit are electrically connected in a first main surface of the body, and a line portion in which the signal line is provided, the line portion extending from the connection portion;

in the first ground conductor, a conductor-missing portion is provided in at least a portion of a region overlapping with the signal line, in a planar view from a lamination direction in the connection portion; and

the adjustment conductor is provided in a second main surface of the body, and overlaps with at least a portion of the conductor-missing portion in the planar view from the lamination direction; and

## 33

the adjustment conductor is not provided in the line portion.

14. The electronic device according to claim 13, wherein a portion of the adjustment conductor overlaps with the signal line in the planar view of the body from the lamination direction.

15. The electronic device according to claim 13, wherein the adjustment conductor includes an insulating substrate in which a metal plate or a conductor layer is provided.

16. The electronic device according to claim 13, wherein the adjustment conductor is fixed to the body via an adhesive or a resist material.

17. The electronic device according to claim 13, wherein the adjustment conductor is not electrically connected to the signal line or the first ground conductor.

18. The electronic device according to claim 13, wherein the first ground conductor is provided on the first main surface side of the body, compared with the signal line.

19. The electronic device according to claim 13, further comprising:

## 34

a second ground conductor provided on the first main surface side of the body, compared with the signal line, and facing the signal line across at least one of the plurality of insulator layers; wherein

the first ground conductor is provided on the second main surface side of the body, compared with the signal line; and

a plurality of openings are provided in at least one of the first ground conductor and the second ground conductor, the plurality of openings being arranged along the signal line in the planar view from the lamination direction.

20. The electronic device according to claim 19, wherein a characteristic impedance of the signal line in a first region overlapping with the openings is higher than a characteristic impedance of the signal line in a second region not overlapping with the openings; and

the characteristic impedance of the signal line in the first region and the characteristic impedance of the signal line in the second region are set so that a characteristic impedance of an entirety of the signal line is a predetermined characteristic impedance.

\* \* \* \* \*